2019

U.S. Geological Survey- Northern Prairie Wildlife Research Center 2017 Research Activity Report

Mark H. Sherfy

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U.S. Geological Survey—
Northern Prairie Wildlife Research Center
2017 Research Activity Report

Circular 1451

U.S. Department of the Interior
U.S. Geological Survey

Front cover. Background: Northern Prairie Wildlife Research Center in July 2016, Jamestown, North Dakota. Photograph by U.S. Geological Survey (USGS). Inset photographs, left to right: Leopard frog (by USGS); Yellow-headed blackbird (by Lawrence Igl, USGS); Mallard in flight (by USGS); and monarch butterfly (by Lawrence Igl, USGS). At top of page: whooping crane in flight (by John Knoll, USFWS).

Inside front cover. Wetlands in the Prairie Pothole Region of North America (by Dave Mushet, USGS).

Facing page. An aerial view of the Northern Prairie Wildlife Research Center near Jamestown, North Dakota. Photograph by USGS.

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U.S. Department of the Interior
DAVID BERNHARDT, Acting Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2019

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Suggested citation:
Sherfy, M.H., ed., 2019, U.S. Geological Survey—Northern Prairie Wildlife Research Center 2017 research activity report: U.S. Geological Survey Circular 1451, 63 p., https://doi.org/10.3133/cir1451.

ISSN 1067-084X (print)
ISSN 2330-5703 (online)

ISBN 978-1-4113-4285-9

Acknowledgments

This report is a compilation of input from the scientific staff at the Northern Prairie Wildlife Research Center, whose devotion of time to preparing the content, and more importantly, to completing the underlying research, is greatly appreciated. Michael J. Anteau, David M. Mushet, and Mark T. Wiltermuth provided critical reviews of earlier drafts and made many valuable suggestions about how best to organize and present Northern Prairie's science portfolio. Mona Khalil provided advice on the structure and display of the report. Finally, the Northern Prairie Wildlife Research Center is proud to continue working with the many partners and collaborators who have made much of the science presented here possible.

Trumpeter swans and other waterfowl on a wetland at Lacreek National Wildlife Refuge, South Dakota. Photograph by U.S. Geological Survey.

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Table 1. Research projects constituting the science portfolio at the Northern Prairie Wildlife Research Center during 2016–17 and their alignment with Programs, Lines of Work, and Sub-Lines of Work.....4

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)

Abbreviations

BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
CWD	chronic wasting disease
DOI	Department of the Interior
FWS	U.S. Fish and Wildlife Service
GPS	Global Positioning System
HAPET	Habitat and Population Evaluation Team
LCC	Landscape Conservation Cooperative
lidar	light detection and ranging
NPAM	Native Prairie Adaptive Management
NPWRC	Northern Prairie Wildlife Research Center
PHyLiSS	Pothole Hydrology Linked System Simulator mode
PPJV	Prairie Pothole Joint Venture
PRRIP	Platte River Recovery Implementation Program
RWBJV	Rainwater Basin Joint Venture
Sub-LOW	Sub-Lines of Work
USACE	U.S. Army Corps of Engineering
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

U.S. Geological Survey—Northern Prairie Wildlife Research Center 2017 Research Activity Report

Edited by Mark H. Sherfy

Center Mission and Science Strategy

The Department of the Interior (DOI) manages the natural and cultural resources of the United States, including public lands and minerals, national parks, national wildlife refuges, and western water resources. The DOI is also responsible for migratory wildlife conservation; historic preservation; endangered species conservation; protection and restoration of surface-mined lands; and mapping geological, hydrological, and biological science for the Nation. The breadth of this mission requires scientific expertise in several disciplines to make informed and defensible management decisions on behalf of the American public. Much of this expertise is provided by way of the U.S. Geological Survey (USGS), the Nation's premier earth and biological science agency. Specifically, USGS biological and ecological research is largely conducted through a network of 16 science centers located throughout the Nation, each representing a distinct component of the USGS mission and a unique focal area of expertise in natural resource science.

The Northern Prairie Wildlife Research Center (NPWRC) was established in 1965 to address key information needs for managing productivity of nationally significant waterfowl populations and habitats. Located in the heart of the Nation's prairie wetland and grassland resources, the center is ideally positioned for interdisciplinary research on migratory birds, land-use change, and wetland and grassland wildlife; and quantifying ecosystem services as affected by land management, conservation programs, and climate variability. During its more than 50-year history, the Center has produced a wealth of information on applied management issues, focusing on the priorities and footprint of the DOI. The Center has also developed long-standing and productive partnerships with a variety of land-management agencies, nonprofit organizations, and universities, fostering opportunities for creative and cost-effective solutions to management and conservation issues.

Today, the Center's science program is organized around five broad themes: (1) wildlife science, (2) ecosystems science, (3) climate-change science, (4) land-use-change science, and (5) analytics and decision support. Together, research conducted under these themes addresses the primary science information needs of land managers and policymakers across a vast portion of the Central United States and is strategically linked through our organizational structure to facilitate interdisciplinary collaboration to address complex issues.

DOI Mission—The DOI protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to Native Americans, Alaska Natives, and affiliated island communities.

USGS Mission—The USGS provides science about the natural hazards that threaten lives and livelihoods; the water, energy, minerals, and other natural resources we rely on; the health of our ecosystems and environment; and the impacts of climate and land-use change. USGS scientists develop new methods and tools to supply timely, relevant, and useful information about the Earth and its processes.

NPWRC Mission—The mission of the NPWRC is to provide scientific information needed to conserve and manage the Nation's natural capital for current and future generations, with an emphasis on migratory birds, DOI trust resources, and ecosystems of the Nation's interior.

The NPWRC celebrated its 50-year anniversary in 2015 and published a report describing the first 50 years of biological research conducted at the Center (Austin and others, 2017) along with a bibliography of scientific products (U.S. Geological Survey, 2017). The scientific foundation developed at the Center during this timeframe provides the base for conducting applied research and enables the Center to quickly respond to emerging issues in the Northern Great Plains and beyond. This report builds on Austin and others (2017) by providing details on the studies that constituted the NPWRC's science portfolio during fiscal years 2016–17.

Lines of Work

The NPWRC's science portfolio is built around a diverse suite of management questions, partnerships, and funding sources. The USGS Ecosystems Mission Area accounts for most of the Center's appropriated funding and has developed a hierarchical system for Centers to classify their biological research portfolios into Lines of Work. The highest level of the hierarchy contains three research Programs, each of which contains two Lines of Work, which in turn contain numerous science subjects, or Sub-Lines of Work [Sub-LOW], as summarized parenthetically below:

The Species Management Program encompasses research on *Species Biology* (research into life history, successful conservation, and recovery of threatened and endangered species listed under the Endangered Species Act; trust species that are protected by law; sensitive species that are declining, rare, or uncommon and are identified as candidates for future listing consideration; and species of management concern that warrant management or conservation attention as identified by a natural resource management agency) and *Species Stressors* (research into the cause and mitigation of environmental and anthropogenic stressors that potentially affect the health and reproductive capacity of species of management concern).

The Landscape Management Program encompasses research on *Management and Restoration* (understanding how ecosystems work and how chemical, geological, hydrological, and biological processes interact and change with human and natural alterations) and *Priority Landscapes* (place-based research to understand the biological and physical processes that influence change and management options across large geographic areas of management concern).

The Biological Threats Program encompasses research on *Invasive Species* (research, monitoring, and technology development for containing or eradicating nonindigenous species with potential to cause significant ecologic or economic damage or impact human health) and *Fish and Wildlife Disease* (ecology of fish and wildlife diseases, impact of diseases on wild populations with emphasis on Federally listed species; development of surveillance, control, and risk-assessment tools; and decision support science to management agencies).

All photographs and illustrations in this report are by U.S. Geological Survey except where otherwise noted.

This hierarchical system has become a standard mechanism for organizing and communicating the Center's science program within the Ecosystems Mission Area. Accordingly, we have adopted its principles for this report. Narratives describing each study are organized according to their principal alignment with Programs, Lines of Work, and Sub-LOWs. Each study is also associated with additional Sub-LOWs as needed to represent the subject area(s) of the study. A cross-reference of active Center studies to these hierarchical levels is provided in table 1 on the following pages.

Grassland Ecosystems—Temperate grasslands are one of the most imperiled ecosystems globally, facing threats including conversion to crop production, invasion by non-native species, and loss of disturbance factors that favor diverse native plant communities.

Northern Forests—Northern hardwood and conifer forest communities from the upper Midwest to the Rocky Mountains support ungulate and carnivore populations that are Federal management priorities owing to their population status and occupancy on Federal lands.

Prairie Pothole Region—Known as "the duck factory" because it supports the core breeding population of many migratory waterfowl species, the Prairie Pothole Region contains millions of depressional, glacially derived wetlands with dynamic and variable hydroperiods that generate periodic pulses of productivity.

Midcontinent River Systems—Large river systems, such as the Missouri, Platte, and Mississippi Rivers, are major landscape features that provide ecosystem services, support populations of priority species, and provide linkages between terrestrial and aquatic habitats.

Table 1. Research projects constituting the science portfolio at the Northern Prairie Wildlife Research Center during 2016–17 and their alignment with Programs, Lines of Work, and Sub-Lines of Work.

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Principal investigator	Study	No. of graduate students	Species management: species biology								
		Student study	T&E: listed birds	T&E: listed insects	T&E: whooping crane	T&E: wolves	SMC: migratory birds	SMC: pollinators	SMC: ungulate ecology	SMC: waterbird management	Population dynamics
Shaffer	Provide support to the U.S. Fish and Wildlife Service and Prairie Pothole Joint Venture for monitoring and management of migratory bird populations	--	--	--	--	--	1	--	--	2	--
Pearse	An evaluation of waterfowl breeding ecology in the context of their predator community in eastern South Dakota	1	--	--	--	--	1	--	--	2	2
Anteau	Demographic analysis of waterfowl populations	1	--	--	--	--	1	--	--	2	2
Austin	Long-term changes in wetland and prairie landscapes	1	--	--	--	--	1	--	--	--	--
Igl	Developing techniques to census and monitor American white pelicans and other colonial waterbirds at Chase Lake National Wildlife Refuge in North Dakota	--	--	--	--	--	1	--	--	2	2
Austin	Distribution and habitat use of waterbirds	--	--	--	--	--	1	--	--	2	--
Igl	Breeding bird use of grasslands enrolled in the CRP in the northern Great Plains	--	--	--	--	--	1	--	--	--	2
Igl	Response of grassland birds to habitat characteristics, oil wells, and roads in managed grasslands in the Little Missouri National Grassland in North Dakota	1	--	--	--	--	1	--	--	--	--
Igl/J. Shaffer	The effects of management on grassland birds—literature reviews	--	--	--	--	--	1	--	--	--	--
Igl	Immune components in eggs of New World blackbirds	--	--	--	--	--	1	--	--	--	--
Pearse	Ecology and management of midcontinent sandhill cranes	--	--	--	--	--	1	--	--	--	--

Species management: species stressors								Landscape management: management and restoration										Biological threats: invasive species			Fish and wildlife disease
																			
Agriculture	Biofuels	Contaminants	Cumulative stressors	Habitat loss/degradation	Hydropower	Oil and gas	Wind energy	Climate change	Decision analysis frameworks	Ecosystem health	Ecosystem services	Fire	Land management practices	Landscape ecology	Remediation/revitalization	Riparian/wetland	River	Ecology and/or impacts	Management and control tools	Risk assessment, decision science, forecasting	Ecology and/or Impacts
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Table 1. Research projects constituting the science portfolio at the Northern Prairie Wildlife Research Center during 2016–17 and their alignment with Programs, Lines of Work, and Sub-Lines of Work.—Continued

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Principal investigator	Study	No. of graduate students	Species management: species biology								
		Student study	T&E: listed birds	T&E: listed insects	T&E: whooping crane	T&E: wolves	SMC: migratory birds	SMC: pollinators	SMC: ungulate ecology	SMC: waterbird management	Population dynamics
Pearse	Development of survey methods for spring-migrating waterfowl in the Rainwater Basin	--	--	--	--	--	1	--	--	2	--
Shaffer	Investigating roadside bias in point-count surveys of grassland passerines	--	--	--	--	--	1	--	--	--	2
Anteau	Demographic response of least terns and piping plovers to the 2011 Missouri River flood	--	1	--	--	--	2	--	--	--	2
Anteau	Metapopulation dynamics of piping plovers in the Northern Great Plains	1	1	--	--	--	2	--	--	--	2
Anteau	Breeding ecology and demographics of least terns and piping plovers at the central Platte River, Nebraska	--	1	--	--	--	2	--	--	2	2
Anteau	Population demographics of least terns and piping plovers in Colorado,	--	1	--	--	--	2	--	--	--	2
Sherfy	Improving monitoring techniques for nests of interior least terns and piping plovers	1	1	--	--	--	2	--	--	--	2
Pearse	Migration and winter ecology of the Aransas-Wood Buffalo population of whooping cranes	--	--	--	1	--	2	--	--	--	2
Otto	Understanding how land-use change in the Northern Great Plains affects pollinator health and pollination services	--	--	--	--	--	--	1	--	--	--
Otto	Improving forage for honey bees and native pollinators on Federal conservation lands	--	--	--	--	--	--	1	--	--	--
Igl	Long-term changes in pollinator resources (alfalfa, sweetclover, milkweed)and Monarch butterfly populations in CRP grasslands	--	--	--	--	--	--	1	--	--	--
Larson	To control or not to control—response of pollinator communities to invasive plant management	--	--	--	--	--	--	1	--	--	--

Species management: species stressors								Landscape management: management and restoration										Biological threats: invasive species			Fish and wildlife disease
Agriculture	Biofuels	Contaminants	Cumulative stressors	Habitat loss/degradation	Hydropower	Oil and gas	Wind energy	Climate change	Decision analysis frameworks	Ecosystem health	Ecosystem services	Fire	Land management practices	Landscape ecology	Remediation/revitalization	Riparian/wetland	River	Ecology and/or impacts	Management and control tools	Risk assessment, decision science, forecasting	Ecology and/or Impacts
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Table 1. Research projects constituting the science portfolio at the Northern Prairie Wildlife Research Center during 2016–17 and their alignment with Programs, Lines of Work, and Sub-Lines of Work.—Continued

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Otto	The pollinator library—a decision-support tool for improving national pollinator conservation efforts	--	--	--	--	--	--	1	--	--	--
Post van der Burg	Developing a sampling and modeling framework to support Dakota skipper management decisions	--	--	1	--	--	--	--	--	--	--
Mech	Superior National Forest wolf population trajectory	--	--	--	--	1	--	--	--	--	2
Mech	Yellowstone wolf restoration	1	--	--	--	1	--	--	--	--	2
Mech	Ellesmere wolf movements	--	--	--	--	1	--	--	--	--	2
Sargeant	Integrated conservation of bison and native prairie at Badlands National Park, South Dakota	--	--	--	--	--	--	--	1	--	2
Post van der Burg	Spatiotemporal dynamics of grassland songbird populations in response to energy development in an agricultural landscape	--	--	--	--	--	2	--	--	--	--
Post van der Burg	Monitoring and modeling wetland chloride concentrations in relationship to oil and gas development	--	--	--	--	--	--	--	--	--	--
Otto	Quantifying the effects of land-use change and bioenergy crop production on ecosystem services in the Northern Great Plains	--	--	--	--	--	--	2	--	--	--
Bansal	Assessment of greenhouse gas fluxes from wetland catchments in the Prairie Pothole Region	--	--	--	--	--	--	--	--	--	--
Anteau/Igl	Can wetland water-management influence mercury bioaccumulation in songbirds and ducks at National Wildlife Refuges with mercury problems?	--	--	--	--	--	2	--	--	--	--

Species management: species stressors								Landscape management: management and restoration										Biological threats: invasive species			Fish and wildlife disease
																					
Agriculture	Biofuels	Contaminants	Cumulative stressors	Habitat loss/degradation	Hydropower	Oil and gas	Wind energy	Climate change	Decision analysis frameworks	Ecosystem health	Ecosystem services	Fire	Land management practices	Landscape ecology	Remediation/revitalization	Riparian/wetland	River	Ecology and/or impacts	Management and control tools	Risk assessment, decision science, forecasting	Ecology and/or Impacts
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Table 1. Research projects constituting the science portfolio at the Northern Prairie Wildlife Research Center during 2016–17 and their alignment with Programs, Lines of Work, and Sub-Lines of Work.—Continued

[Icons from www.flaticon.com, Creative Commons 3.0 license. Numerals represent the primary (1) and secondary (2) alignment with Programs, Lines of Work, and Sub-Lines of Work. Numerals in the graduate student study column represent the number of graduate students pursuing degrees on that study. No., number; T&E, threatened and endangered; SMC, species of management concern; --, not applicable; CRP, Conservation Reserve Program; USDA, U.S. Department of Agriculture; FORT, Fort Collins Science Center; lidar, light detection and ranging; FWS, U.S. Fish and Wildlife Service; Native Prairie Adaptive Management; ABAM, Annual Brome Adaptive Management]

Principal investigator	Study	No. of graduate students	Species management: species biology								
		Student study	T&E: listed birds	T&E: listed insects	T&E: whooping crane	T&E: wolves	SMC: migratory birds	SMC: pollinators	SMC: ungulate ecology	SMC: waterbird management	Population dynamics
Wiltermuth	Inventory, mapping, estimation, and monitoring of least tern and piping plover habitats on the upper Missouri River using satellite imagery	--	2	--	--	--	2	--	--	--	--
Post van der Burg	Potential effects of energy development on environmental resources of the Williston Basin in Montana, North Dakota, and South Dakota	--	--	--	--	--	--	--	--	--	--
Symstad	Model-based scenario planning to inform climate change adaptation in the Northern Great Plains	--	--	--	--	--	--	--	--	--	--
Mushet	USDA CRP Durability Assessment with FORT	--	--	--	--	--	--	--	--	--	--
Newton	Improving wildlife-habitat modeling and assessments with lidar	--	--	--	--	--	--	--	--	--	--
Newton	Impacts of wind-turbine energy complexes on northern prairie grouse	--	--	--	--	--	--	--	--	--	--
Anteau	Interaction of land use and wet/dry cycles on invertebrate populations of northern prairie wetlands—implications for waterbird habitat conservation	1	--	--	--	--	--	--	--	--	--
Anteau	Evaluating wetland ecosystem health using real-time nutrient dynamics of ducks	3	--	--	--	--	2	--	--	--	--
Anteau	Interactions of consolidation drainage and climate on water-level dynamics, wetland productivity, and waterbirds	--	--	--	--	--	--	--	--	--	--
Anteau	Restoration of wetland invertebrates to improve wildlife habitat in Minnesota	2	--	--	--	--	--	--	--	--	--
Anteau	Importance of wetlands in intensively farmed landscapes to waterfowl production	2	--	--	--	--	2	--	--	2	--

Species management: species stressors								Landscape management: management and restoration										Biological threats: invasive species			Fish and wildlife disease
Agriculture	Biofuels	Contaminants	Cumulative stressors	Habitat loss/degradation	Hydropower	Oil and gas	Wind energy	Climate change	Decision analysis frameworks	Ecosystem health	Ecosystem services	Fire	Land management practices	Landscape ecology	Remediation/revitalization	Riparian/wetland	River	Ecology and/or impacts	Management and control tools	Risk assessment, decision science, forecasting	Ecology and/or Impacts
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Principal investigator	Study	No. of graduate students	Species management: species biology								
		Student study	T&E: listed birds	T&E: listed insects	T&E: whooping crane	T&E: wolves	SMC: migratory birds	SMC: pollinators	SMC: ungulate ecology	SMC: waterbird management	Population dynamics
Anteau/Pearse	Understanding consequences of management strategies for farmed wetlands to ecosystem services in the Prairie Pothole Region	1	--	--	--	--	2	--	--	--	--
Mushet	A systems approach to modeling effects of climate and land-use change on prairie-wetland ecosystems	1	--	--	--	--	--	--	--	--	--
Mushet	Development and validation of wetland connectivity indicators in the U.S. Prairie Pothole Region	1	--	--	--	--	--	--	--	--	--
Tangen	Assessment of pattern tile drainage on wetland hydrology and ecosystem services in the Prairie Pothole Region	--	--	--	--	--	--	--	--	--	--
Tangen	Description of aquatic vegetation and invertebrate communities at Big Stone National Wildlife Refuge	--	--	--	--	--	--	--	--	--	--
Mushet	Quantify the multiple services performed by wetland ecosystems in the Prairie Pothole Region of the United States	--	--	--	--	--	--	--	--	--	--
Mushet	Quantifying ecosystem services provided by depressional wetlands in the upper Mississippi	--	--	--	--	--	--	--	--	--	--
Post van der Burg	Science support for Landscape Conservation Cooperatives	--	--	--	--	--	--	--	--	--	--
Post van der Burg	Decision analysis and support	--	--	--	--	--	--	--	--	--	--
Wiltermuth	Data integration and information synthesis	--	--	--	--	--	--	--	--	--	--
Mushet	Managing upland vegetation as a mitigation strategy for climate change effects on prairie-pothole wetlands	1	--	--	--	--	--	--	--	--	--

Species management: species stressors								Landscape management: management and restoration										Biological threats: invasive species			Fish and wildlife disease
Agriculture	Biofuels	Contaminants	Cumulative stressors	Habitat loss/degradation	Hydropower	Oil and gas	Wind energy	Climate change	Decision analysis frameworks	Ecosystem health	Ecosystem services	Fire	Land management practices	Landscape ecology	Remediation/revitalization	Riparian/wetland	River	Ecology and/or impacts	Management and control tools	Risk assessment, decision science, forecasting	Ecology and/or Impacts
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Table 1. Research projects constituting the science portfolio at the Northern Prairie Wildlife Research Center during 2016–17 and their alignment with Programs, Lines of Work, and Sub-Lines of Work.—Continued

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Principal investigator	Study	No. of graduate students	Species management: species biology								
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Larson	Evaluation of conservation grazing compared to prescribed fire to manage tallgrass prairie remnants for plant and pollinator species diversity	2	--	--	--	--	--	2	--	--	--
Larson	Effects of invasive plant species on reproduction of the rare endemic plant Dakota buckwheat (*Eriogonum visheri*) at Badlands National Park	--	--	--	--	--	--	--	--	--	--
Larson	Evaluation of tallgrass prairie restoration methods to improve resistance to invasive species and maintenance of plant species diversity over time	--	--	--	--	--	--	--	--	--	--
Larson	Developing evaluation and monitoring frameworks for tallgrass prairie reconstruction	--	--	--	--	--	--	--	--	--	--
Shaffer	Improving wildlife habitat through management and restoration of native prairies on lands under FWS ownership	--	--	--	--	--	2	--	--	--	--
Igl	Decision support for restoration and management of FWS-owned native prairies (NPAM)—implications for grassland bird communities	--	--	--	--	--	2	--	--	--	--
Symstad	What role does prescribed fire play in managing annual bromes in Northern Great Plains grasslands?	--	--	--	--	--	--	--	--	--	--
Symstad	An adaptive management framework to control invasive annual brome grasses in Northern Great Plains parks (ABAM)	--	--	--	--	--	--	--	--	--	--
Symstad	Grazing resources for integrated conservation of bison and native prairie at Badlands National Park, South Dakota	--	--	--	--	--	--	--	2	--	--
Sargeant	Effects of population density on prevalence of chronic wasting disease (CWD), physical condition, and vital rates of elk at Wind Cave National Park, South Dakota	--	--	--	--	--	--	--	2	--	2

Species management: species stressors								Landscape management: management and restoration										Biological threats: invasive species			Fish and wildlife disease
Agriculture	Biofuels	Contaminants	Cumulative stressors	Habitat loss/degradation	Hydropower	Oil and gas	Wind energy	Climate change	Decision analysis frameworks	Ecosystem health	Ecosystem services	Fire	Land management practices	Landscape ecology	Remediation/revitalization	Riparian/wetland	River	Ecology and/or impacts	Management and control tools	Risk assessment, decision science, forecasting	Ecology and/or Impacts
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Study Narratives

Species Biology

1. Provide Support to the U.S. Fish and Wildlife Service and Prairie Pothole Joint Venture for Monitoring and Management of Migratory Bird Populations

Sound management of migratory bird breeding populations in the U.S. Prairie Pothole Region hinges on effective monitoring programs and comprehensive analyses of long-term survey data. To this end, the NPWRC provides support to the U.S. Fish and Wildlife Service (FWS) in several important areas. The Four-Square-Mile Breeding Duck and Habitat Survey was developed by the NPWRC in the mid-1980s and has been conducted annually by FWS refuge personnel under leadership by their Habitat and Population Evaluation Team (HAPET) since the late 1980s. A concurrent effort to assemble and archive information on duck nest survival from studies conducted by the NPWRC and dozens of partners has resulted in a database of nearly 150,000 nest records spanning 62 years, 11 States, and 3 Provinces. The NPWRC, in cooperation with HAPET, periodically analyzes these two long-term datasets to improve understanding of duck settling ecology and to update estimates of duck nest survival. These and other analyses fuel decision support tools used by Prairie Pothole Joint Venture (PPJV) partners to prioritize and target conservation efforts.

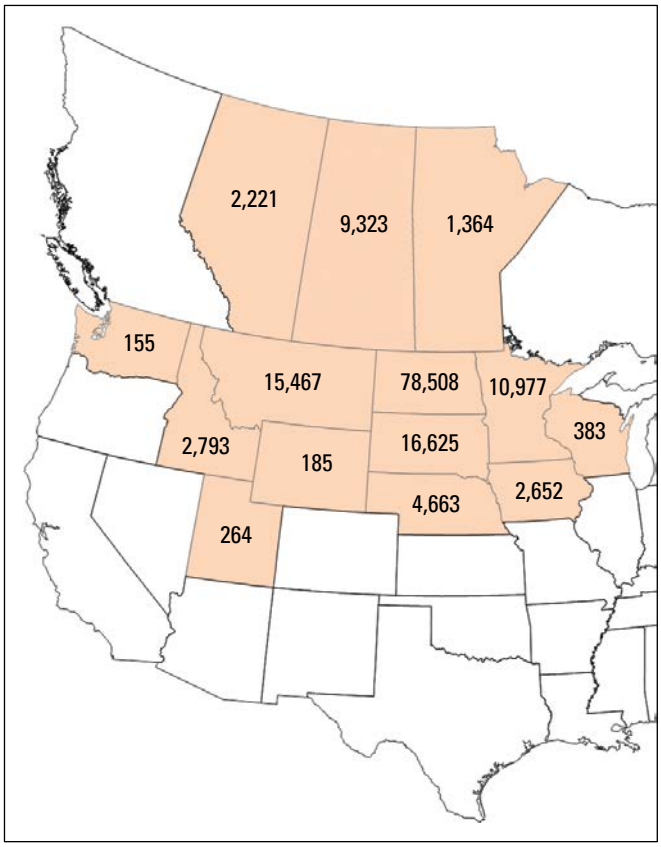
Contact: Terry L. Shaffer, tshaffer@usgs.gov, 701–253–5522

Collaborators: FWS, HAPET, National Wildlife Refuge System; PPJV

Products:

Grant, T.A., Shaffer, T.L., Madden, E.M., and Nenneman, M.P., 2017, Contrasting nest survival patterns for ducks and songbirds in northern mixed-grass prairie: The Journal of Wildlife Management, v. 81, no. 4, p. 641–651, https://doi.org/10.1002/jwmg.21224.

Murphy, R.K., Shaffer, T.L., Grant, T.A., Derrig, J.L., Rubin, C.S., and Kerns, C.K., 2017, Sparrow nest survival in relation to prescribed fire and woody plant invasion in a northern mixed-grass prairie: Wildlife Society Bulletin, v. 41, no. 3, p. 442–452, https://doi.org/10.1002/wsb.780.



Spatial distribution and count of nest records (1956–2017) that have been compiled and archived in the nest record file maintained at the Northern Prairie Wildlife Research Center.

2. An Evaluation of Waterfowl Breeding Ecology in the Context of Their Predator Community in Eastern South Dakota

Population growth in upland-nesting ducks is highly influenced by spatial and temporal variation in nest survival, and mammalian predators are the major cause of nest failure. Beginning in spring 2018, the NPWRC will study predator communities and their movements in landscapes with varying grassland patch composition, while concurrently investigating nest site selection and survival of upland duck nests. We anticipate that findings from this study will increase understanding of how grassland patches and vegetation composition, diversity, and structural heterogeneity affect predator habitat use, movements, and survival of upland duck nests. We will use results to evaluate comprehensive management strategies for remnant grasslands, restoration efforts, and active management programs that want to modify grassland regimes to improve nesting habitat.

Contact: Aaron T. Pearse, apearse@usgs.gov, 701–253–5509

Collaborators: USGS South Dakota Cooperative Fish and Wildlife Research Unit (Lead Agency); South Dakota State University; South Dakota Department of Game, Fish, and Parks

3. Demographic Analysis of Waterfowl Populations

The NPWRC has a long history of conducting broad-scale demographic analyses on available waterfowl. Our current efforts are collaborative with a variety of partners. Current studies include (1) analysis of banding data for lesser scaup to inform the role of harvest on the continental population; (2) analysis of North American survey information of mallards (*Anas platyrhynchos*) to identify consistent hot and cold spots of density to inform conservation activities; (3) analysis of mid-continent waterfowl harvest information to identify predictable drivers of recruitment; and (4) evaluation of the North American survey for sources of changing bias in survey methods. The NPWRC recognizes the cultural and socioeconomic importance of waterfowl in North America, and each of these analyses are conducted to inform pressing conservation decisions that are made by partners.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: FWS, Division of Migratory Bird Management; North Dakota Game and Fish Department; Duke University; Louisiana State University; South Dakota State University, USGS South Dakota Cooperative Fish and Wildlife Research Unit; University of Minnesota

Products:

Arnold, T.W., Afton, A.D., Anteau, M.J., Koons, D.N., and Nicolai, C.A., 2016, Temporal variation in survival and recovery rates of lesser scaup: The Journal of Wildlife Management, v. 80, no. 5, p. 850–861, https://doi.org/10.1002/jwmg.21074.

Arnold, T.W., Afton, A.D., Anteau, M.J., Koons, D.N., and Nicolai, C.A., 2017, Temporal variation in survival and recovery rates of lesser scaup—A response: The Journal of Wildlife Management, v. 81, no. 7, p. 1142–1148, https://doi.org/10.1002/jwmg.21315.

Janke, A.K., Anteau, M.J., and Stafford, J.D., 2017, Long-term spatial heterogeneity in mallard distribution in the Prairie Pothole Region: Wildlife Society Bulletin, v. 41, no. 1, p. 116–124, https://doi.org/10.1002/wsb.747.

The annual economic footprint of waterfowl hunting is more than $3 billion. Photograph by Glen Sargeant, USGS.

4. Long-term Changes in Wetland and Prairie Landscapes

During the past 50 years, wetlands in the Prairie Pothole Region of the Northern Great Plains have experienced a wide range of climatic conditions (severe drought to extreme wet), expansion of invasive species such as hybrid cattail, and disturbances (for example, grazing, burning, flooding, drainage). In this study, we revisited wetlands that Stewart and Kantrud (1971) studied 50 years ago to evaluate changes in hydrological features and plant community. The three study areas encompassed fresh to saline wetland systems and had different topographic and edaphic conditions. Climatic extremes greatly impacted wetland size, depths, and specific conductivity for Crystal Springs and Cottonwood study areas, whereas wetlands at Mt. Moriah appeared more resilient. Climatic extremes, in combination with invasive plant species, greatly impacted species composition, frequency, and abundance of individual plant species in plant communities within wetland zones across all three study areas. This study demonstrates the value of long-term monitoring and provides valuable insights on how wetland systems respond to interactions of climate, topography, and land use.

Contact: Jane E. Austin, jaustin@usgs.gov, 701–253–5510

Collaborators: USGS South Dakota Cooperative Fish and Wildlife Research Unit, FWS, Chase Lake Wetland Management District

Products:

Cressey, R.L., 2016, Changes in wetland conditions and wetland plant communities in the PPR after 50 years: Brookings, South Dakota, MS thesis, South Dakota State University, Paper 1001, http://openprairie.sdstate.edu/etd/1001.

Cressey, R.L., Austin, J.E., and Stafford, J.D., 2016, Three responses of wetland conditions to climatic extremes in the Prairie Pothole Region: Wetlands, v. 36, no. S2, suppl. 2, p. 357–370, https://doi.org/10.1007/s13157-016-0818-8.

5. Developing Techniques to Census and Monitor American White Pelicans and Other Colonial Waterbirds at Chase Lake National Wildlife Refuge in North Dakota

Monitoring is essential to detect colonial waterbirds and to provide insights about changes in waterbird distribution and abundance. For colonial waterbirds, major population fluctuations often go undetected because surveys are not conducted regularly, inventory methods are inconsistent, or estimates have unknown reliability. The waterbird colony at Chase Lake National Wildlife Refuge in North Dakota is one of the largest nesting colonies in the region and has changed dramatically during the past two decades. The colony has increased both in species composition and overall numbers. Many of these changes remain unquantified. The NPWRC is developing and assessing methods to estimate breeding populations of ground- and shrub-nesting waterbirds at Chase Lake. The goal is to develop reliable methods for estimating the size of breeding populations for different waterbird species and to provide protocols for monitoring colonial species at Chase Lake National Wildlife Refuge. The results from this study will increase our knowledge of waterbird populations at this refuge and provide techniques for long-term monitoring of colonial waterbird populations. The methods also will be applicable to other island-nesting waterbird colonies with similar attributes in the region and elsewhere.

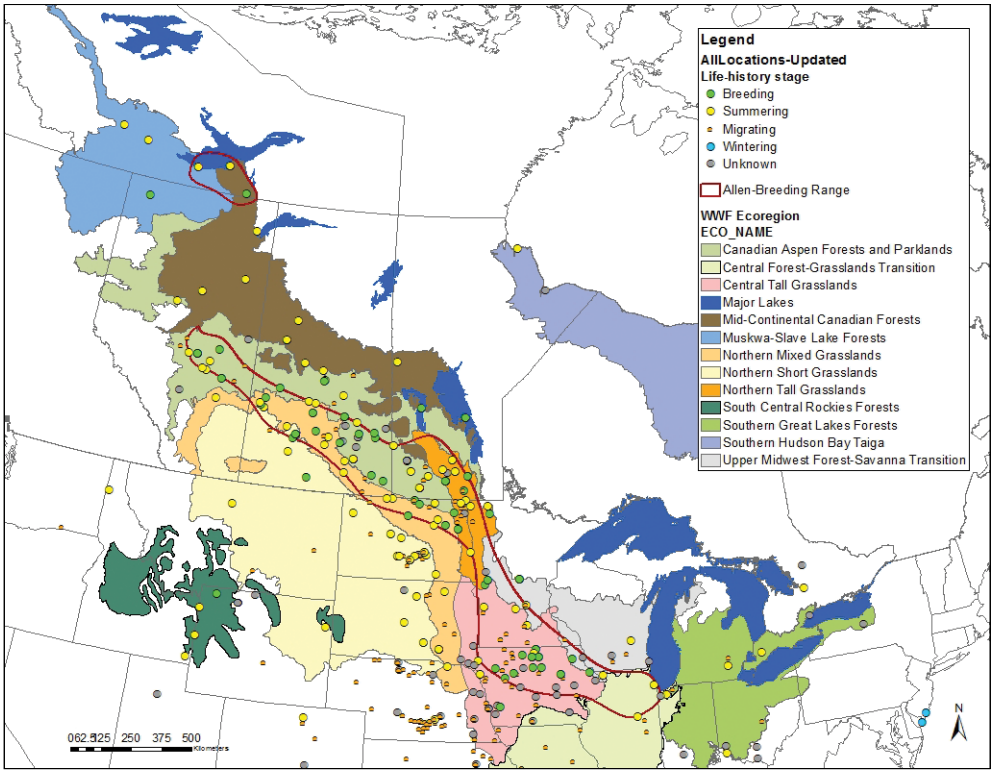
Collaborators: FWS, Chase Lake Wetland Management District, Chase Lake National Wildlife Refuge, Arrowwood National Wildlife Refuge Complex

Contact: Lawrence D. Igl, ligl@usgs.gov, 701–253–5511

Great egret and American white pelicans at a multispecies waterbird nesting colony at Chase Lake National Wildlife Refuge. Photograph by Alisa Bartos, U.S. Fish and Wildlife Service.

6. Distribution and Habitat Use of Waterbirds

Waterbird distribution and habitat use are affected by human activities of agriculture and land-management practices, such as grazing or burning. For many waterbird species, our knowledge of their ecology and of factors affecting their abundance and importance of different habitats is very limited. Such information can help direct more effective habitat restoration, management, and conservation programs as well as improve population management activities and modeling. Encompassed within this project are four topics relating avian distribution and habitat use to wetland conditions, land use, and management: (1) habitat selection by postbreeding lesser scaup; (2) re-evaluation of historic distribution and habitat use patterns of whooping cranes to inform conservation actions; (3) role of fire in sedge-shrub systems, affecting plant community and structure and birds of conservation concern; and (4) a global synthesis of information of the crane-agricultural nexus, to serve conservation practitioners, decision-makers, communities, and farmers, for the development of more effective and sustainable conservation programs that address specific local or regional challenges.



Locations of historic Whooping Crane records, 1722–1941, by life history stage, in northern breeding and summering areas, overlaid on World Wildlife Fund ecoregions and the Prairie Pothole Region.

Contact: Jane E. Austin, jaustin@usgs.gov, 701–253–5510

Collaborators: FWS, Seney National Wildlife Refuge; International Crane Foundation

Products:

Austin, J.E., in press, Threats to cranes related to agriculture, *in* Austin, J.E., Morrison, K., and Harris, J., eds., Handbook on cranes and agriculture—A global guide for sharing the landscape: Baraboo, Wisconsin, International Crane Foundation.

Austin, J.E., Hayes, M.A., and Barzen, J.A., in press, Revisiting the historic distribution and habitats of the whooping crane, *in* French, J.B., Converse, S.J., and Austin, J.E., eds., The biology and conservation of the whooping crane: San Diego, California, Academic Press, https://doi.org/10.1016/B978-0-12-803555-9.00003-7

Austin, J.E., Hayes, M.A., and Barzen, J.A., 2017, Whooping crane historic observation records, 1722-1941: U.S. Geological Survey data release, https://dx.doi.org/10.5066/F7QZ282R.

Austin, J.E., O'Neil, S.T., and Warren, J.M., 2017, Habitat selection by postbreeding female diving ducks—Influence of habitat attributes and conspecifics: Journal of Avian Biology, v. 48, no. 2, p. 295–308, https://doi.org/10.1111/jav.01063.

Austin, J.E., Momose, K., and Archibald, G., in press, Interactions and impacts of domesticated animals on cranes in agriculture, *in* Austin, J.E., Morrison, K., and Harris, J., eds., Handbook on cranes and agriculture—A global guide for sharing the landscape: Baraboo, Wisconsin, International Crane Foundation.

Austin, J.E., Morrison, K., and Harris, J., eds., in press, Handbook on cranes and agriculture—A global guide for sharing the landscape: Baraboo, Wisconsin, International Crane Foundation.

Austin, J.E., and Sundar, K.G., in press, Methods to reduce conflicts between cranes and farmer, *in* Austin, J.E., Morrison, K., and Harris, J., eds., Handbook on cranes and agriculture—A global guide for sharing the landscape: Baraboo, Wisconsin, International Crane Foundation.

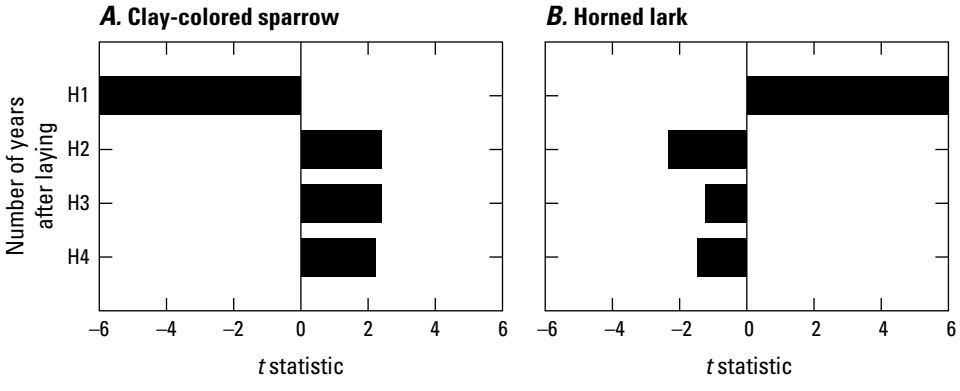
Austin, J.E., and Warren, J., 2016, Survey and habitat data for postbreeding lesser scaup, Lower Red Rock Lake, MT, 2007–2013: U.S. Geological Survey data release, http://dx.doi.org/10.5066/F7X34VJ2.

7. Breeding Bird Use of Grasslands Enrolled in the Conservation Reserve Program in the Northern Great Plains

Biological science technician surveying breeding birds on idle and hayed portions of a Conservation Reserve Program grassland in Sheridan County, Montana Photograph by Lawrence D. Igl, U.S. Geological Survey.

Agriculture is the dominant land use on privately owned lands in the Northern Great Plains of the United States. Management decisions on agricultural lands are heavily influenced by a variety of policies and programs established by the Federal Government in periodic Farm Bills. In 1985, Congress passed the Food Security Act. Title XII of the Act established the Conservation Reserve Program (CRP), a voluntary, long-term, cropland retirement program that is available to agricultural producers to help safeguard environmentally sensitive land. In collaboration with the U.S. Department of Agriculture (USDA), since 1990, the NPWRC has been evaluating breeding bird use of several hundred grasslands enrolled in the CRP in four states (North Dakota, South Dakota, Minnesota, and Montana) in the Northern Great Plains. This is the longest and most extensive evaluation of CRP grasslands and breeding birds of its kind. Results from this and allied studies have been used to generate support for renewal of the CRP in subsequent Farm Bills and to make the Prairie Pothole Region a high-priority area for CRP in the United States. The results from this study also have served to inform private landowners, managers, and policy makers on program improvements for grassland birds related to CRP management (for example, haying, grazing), grassland patch size, and seeding mixtures (native compared to exotic).

Contact: Lawrence D. Igl, ligl@usgs.gov, 701–253–5511



The strength and direction of a bird species' response to emergency or managed haying in Conservation Reserve Program grasslands varies. The *t*-statistics or *t*-values show comparisons between idle and 1, 2, 3, and 4 years after haying.

Products:

Igl, L.D., and Johnson, D.H., 2016, Effects of haying on breeding birds in CRP grasslands: The Journal of Wildlife Management, v. 80, no. 7, p. 1189–1204, https://doi.org/10.1002/jwmg.21119.

Igl, L.D., Shaffer, J.A., Johnson, D.H., and Buhl, D.A., 2017, The influence of local- and landscape-level factors on wetland breeding birds in the Prairie Pothole Region of North and South Dakota: U.S. Geological Survey Open-File Report 2017–1096, 65 p., https://doi.org/10.3133/ofr20171096.

Collaborators: Private landowners, USDA, Farm Service Agency and Natural Resources Conservation Service

8. Response of Grassland Birds to Habitat Characteristics, Oil Wells, and Roads in Managed Grasslands in the Little Missouri National Grassland in North Dakota

The U.S. Forest Service defines sensitive species as species that need special management to maintain and improve their status on National Forests and Grasslands and to prevent a need for listing under the Endangered Species Act. The Sprague's pipit and Baird's sparrow are listed as sensitive species in the Northern Region of the U.S. Forest Service. These species require large patches of native grass cover throughout their life cycles. Large-scale losses and degradation of critical grassland habitat highlight the importance of appropriate management and conservation measures for remaining native grasslands. In collaboration with the U.S. Forest Service and North Dakota State University, the NPWRC is evaluating the effects of landscape-level (for example, oil development, roads) and site-specific (for example, vegetation structure and composition) factors on populations of Sprague's pipits, Baird's sparrows, and other declining grassland birds in the Little Missouri National Grassland in western North Dakota. The results from this study will contribute to understanding grassland songbird responses to local and landscape factors and identify specific mechanisms by which conservation measures for declining grassland bird populations can be improved.

Little Missouri National Grasslands in western North Dakota (inset: livestock and Baird's sparrow). Photographs by Brian Chepulis, U.S. Geological Survey (grassland and livestock) and David O. Lambeth (Baird's sparrow).

Contact: Lawrence D. Igl, ligl@usgs.gov, 701–253–5511

Products:

Chepulis, B.J., 2016, Grassland bird response to landscape-level and site-specific variables in the Little Missouri National Grassland: Fargo, North Dakota, North Dakota State University, M.S. Thesis.

Collaborators: U.S. Forest Service, North Dakota State University

9. The Effects of Management on Grassland Birds—Literature Reviews

Project: With support from the PPJV, the U.S. Forest Service, and The Nature Conservancy, the NPWRC is synthesizing literature on the effects of management practices on grassland bird species. The need for these syntheses was identified by the PPJV, a part of the North American Waterfowl Management Plan, in support of its objective to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region. More than 5,000 published and unpublished articles in the literature have been incorporated, and syntheses are near completion for 40 North American grassland bird species. Each species account includes information on species range, suitable habitat, area requirements, breeding season phenology, species' response to management, and management recommendations. The final product will provide land managers with a summary of information on the effects of specific management practices on grassland birds and identify for researchers the most critical research gaps in our understanding of grassland bird ecology, habitat needs, and responses to management practices.

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Collaborators: PPJV; FWS, Migratory Bird Program, Denver; U.S. Forest Service, Dakota Prairie Grasslands, Bismarck; The Nature Conservancy

Male lark bunting. Drawing by Christopher Goldade, U.S. Geological Survey.

Adult male bobolink in a grazed grassland. Photographs by Lawrence D. Igl, U.S. Geological Survey.

10. Immune Components in Eggs of New World Blackbirds

Project: Interest in the immune systems of wild birds has increased as public health authorities have recognized that many emerging infectious diseases of wildlife can be transmitted to humans (that is, zoonoses). Eco-immunology is an emerging field that characterizes how immune adaptations of wild species vary as a result of evolution in different habitats and niches. Present understanding of the effect of specific life-history traits and habitat on wild bird immune investment is rudimentary, and few studies have compared multiple immunological parameters of related wild bird species. An NPWRC scientist is a collaborator on this study and compares passive immune components of six songbird species in a single taxonomic family, New World

Candling a red-winged blackbird egg to determine incubation stage (inset: parasitized red-winged blackbird nest). Photograph by Lawrence D. Igl, U.S. Geological Survey.

Yellow-headed blackbird in semipermanent wetland. Photograph by Lawrence D. Igl, U.S. Geological Survey.

blackbirds (*Icteridae*), including two obligate brood parasites. Information from this research will be used to evaluate how the observed differences in immune components in eggs of different species may be related to divergence in life-history traits and ecological niches. This comparative approach contrasts variation in immunity components of several closely related species and will provide a baseline for the degree of between-species variability. This study also will inform broader questions related to the effectiveness of the immune system in resisting infection in species of conservation concern and closely related nonthreatened taxa.

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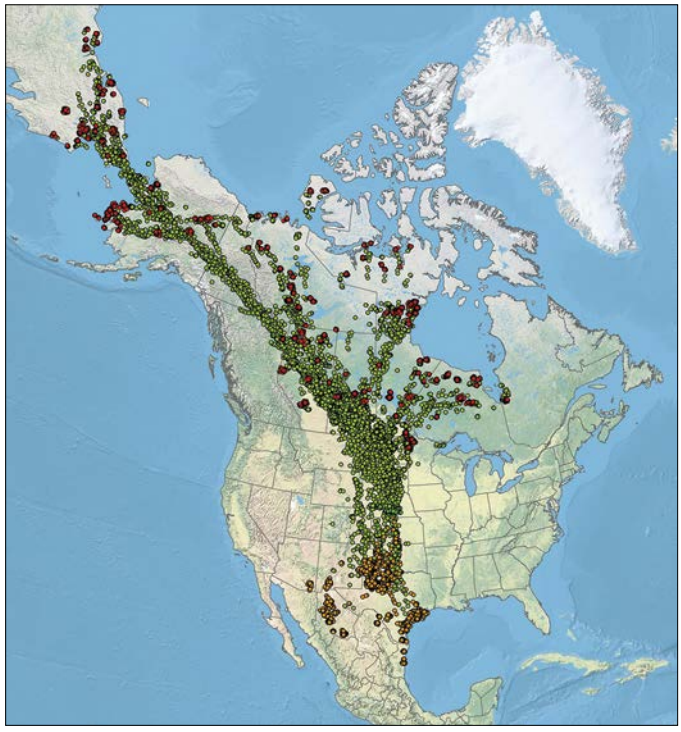
Collaborators: USGS, Patuxent Wildlife Research Center; Creighton University; Departamento de Recursos Naturales y Ambientales de Puerto Rico

11. Ecology and Management of Midcontinent Sandhill Cranes

Sandhill cranes of the midcontinent population occupy a large geographic area of central and western North America and northeastern Asia during breeding, winter, and migration. They are a species representing a unique convergence of multiple user groups with an interest in the continued health of this population. Tens of thousands of people view cranes during spring staging at the Platte River Valley in Nebraska, and hunters pursue and harvest cranes annually in most of their fall and winter range. The overall goal of this project is to



Geographic distribution of midcontinent sandhill cranes as determined by satellite telemetry from cranes marked at the Platte River, Nebraska, United States. This project identified breeding areas (red circles), migration (green circles), and wintering locations (orange circles) that occurred over a broad area within North America and portions of Asia.

provide information that will improve crane management and multiple objectives including determination of geographic distribution, migration chronology, and spring-staging ecology in the Platte River Valley; evaluation of survey methods; estimation of survival and recruitment; and population dynamics modeling. Work completed will provide better-informed harvest management strategies, opportunities for increased international conservation collaboration, conservation of crane habitats at multiple spring stopover sites, and insight into long-term monitoring of habitats and cranes.

Contact: Aaron T. Pearse, apearse@usgs.gov, 701–253–5509

Products:

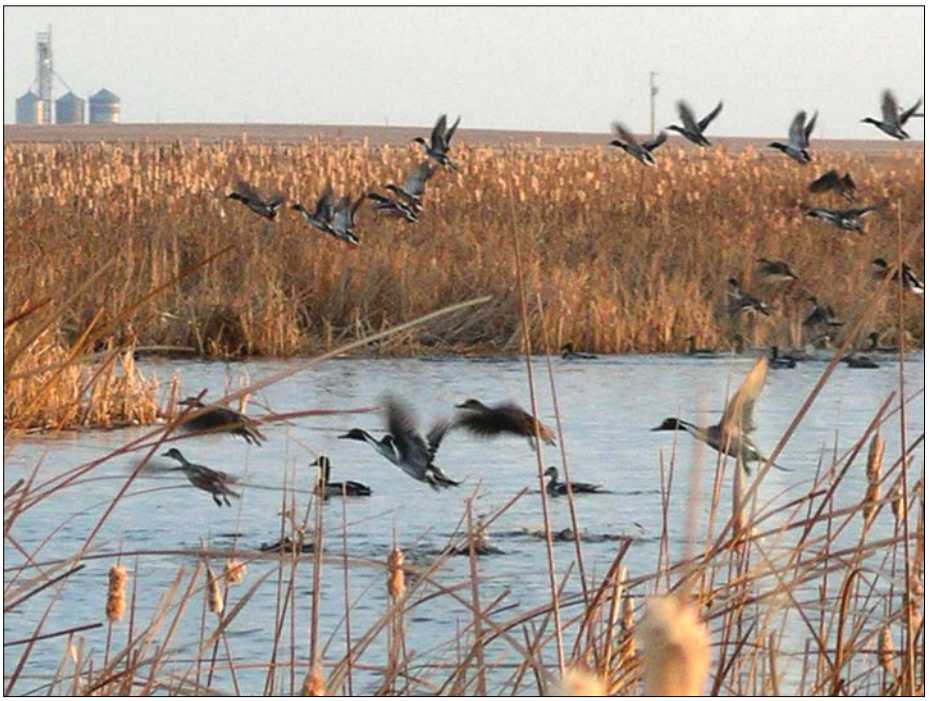
Pearse, A.T., Brandt, D.A., and Krapu, G.L., 2016, Wintering sandhill crane exposure to wind energy development in the central and southern Great Plains, USA: The Condor—Ornithological Applications, v. 118, p. 391–401, https://doi.org/10.1650/CONDOR-15-99.1.

Pearse, A.T., Krapu, G.L., and Brandt, D.A., 2017, Sandhill crane roost selection, human disturbance, and forage resources: The Journal of Wildlife Management, v. 81, no. 3, p. 477–486, https://doi.org/10.1002/jwmg.21215.

Collaborators: FWS, Ecological Services Nebraska Field Office, Rainwater Basin Joint Venture (RWBJV); State and Provincial game and fish agencies of Colorado, Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Wyoming, Montana, New Mexico, Saskatchewan, and Alberta; International Crane Foundation; The Crane Trust; Playa Lakes Joint Venture; Russian Academy of Science–Sakha Division; Central Flyway Council; Texas Tech University; Texas A&M University

12. Development of Survey Methods for Spring-migrating Waterfowl in the Rainwater Basin

The Rainwater Basin Wetland Complex is a mid-latitude focal point of spring migration for numerous species of birds in the Great Plains. The RWBJV and partners desire geospatial models to identify characteristics of wetland complexes and understand local and landscape level factors that affect habitat selection of migrating waterfowl. To support this effort, we developed a monitoring strategy that incorporates the complexities of large spatial and temporal variation in ponded water during spring survey periods. Our strategy relies on the greater than 10 years of surface water data that the RWBJV has collected during spring. Development of these types of models and conservation planning tools requires long-term study; thus, the sampling strategy, which was initiated in 2017, will be conducted annually for the next 10 years to collect data needed to develop models and describe habitat relationships.



Wetlands within the Rainwater Basin in south central Nebraska are randomly selected and visited multiple times each spring to count numbers of ducks and geese. Wetland and landscape characteristics corresponding with these counts will form basis of future conservation planning tools.

Contact: Aaron T. Pearse, apearse@usgs.gov, 701–253–5509

Collaborators: RWBJV; Nebraska Game and Parks Commission; Ducks Unlimited, Inc.

13. Investigating Roadside Bias in Point-Count Surveys of Grassland Passerines

The North American Breeding Bird Survey (BBS) provides much essential information for assessing bird populations, but it is unknown how inherent assumptions of the BBS apply to grassland birds in the Northern Great Plains. Understanding the effects of these assumptions on our understanding of grassland bird populations is essential given widespread declines of grassland birds as well as recent and impending petitions to list some species under the Endangered Species Act. This project is assessing how occurrence and detection of grassland birds are affected by roadside sampling, seasonal timing of surveys, and fine-grained habitat features such as fences and utility lines that are often associated with roads. The study will improve inferences made from spatial models used to guide grassland bird conservation. This study will also allow better interpretation of BBS results, improved understanding of population trends, will inform future population monitoring in the Northern Great Plains, and ultimately increase confidence in population data used in listing decisions.

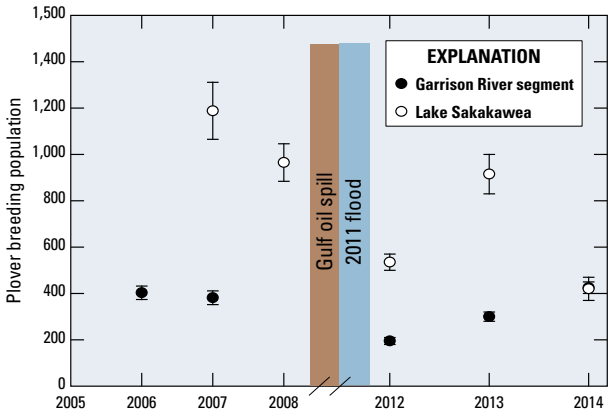
A Northern Prairie Wildlife Research Center seasonal technician conducting a bird survey at a road site, following Breeding Bird Survey procedures. Comparable off-road sites were located 200–1,500 meters away from any road (U.S. Geological Survey photograph).

Contact: Terry L. Shaffer, tshaffer@usgs.gov, 701–253–5522

Collaborators: FWS, HAPET and National Wildlife Refuge System, and Inventory and Monitoring Program

14. Demographic Response of Least Terns and Piping Plovers to the 2011 Missouri River Flood

The largest recorded flood event on the Missouri River occurred during 2011. The NPWRC recently concluded a study that evaluated effects of that flood on least tern and piping plover breeding populations. These federally listed species nest on riverine sandbars and reservoir shorelines. Since construction of the dams on the Missouri River, there have been few floods of a magnitude great enough to create sandbar habitat for these species. We collected breeding productivity data of least terns and piping plovers during 2012–14. We compared estimates of breeding population, nest success, and chick survival at the Garrison River Segment and Lake Sakakawea to estimates from data we collected there from 2006–08. These comparisons informed the U.S. Army Corps of Engineering (USACE) about how quickly newly created habitat is used and provided information about how long quality habitat persists.



Plot of the piping plover breeding population estimates for the Garrison River Segment and Lake Sakakawea before and after the 2011 Missouri River flood.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: USACE, Omaha District, Threatened and Endangered Species Section; FWS, North Dakota Ecological Services Field Office

Products:

Anteau, M.J., Sherfy, M.H., Shaffer, T.L., Swift, R.J., Toy, D.L., and Dovichin, C.M., 2019, Demographic responses of least terns and piping plovers to the 2011 Missouri River flood—A large-scale case study: U.S. Geological Survey Open-File Report 2018–1176, 33 p., https://doi.org/10.3133/ofr20181176.

15. Metapopulation Dynamics of Piping Plovers in the Northern Great Plains

The NPWRC is leading a multiagency regional study to understand metapopulation dynamics of piping plovers in the Northern Great Plains. Piping plovers are a federally listed species that nests on riverine sandbars and shorelines of wetlands and reservoirs. These habitats are dynamic in response to climate and water-management regimes of the Missouri River. The USACE manages the Missouri River for hydropower, recreation, water supply, navigation, flood control, and fish and wildlife. That management strategy puts piping plovers in jeopardy. Accordingly, the USACE is preparing to spend more than $10 million a year for the foreseeable future to create breeding habitat for plovers on the Missouri River. Additionally, the other key areas where plovers breed, wetlands in the Prairie Pothole Region, are under threat from changing climate and land-use practices. The NPWRC recently completed year 6 of an 8-year study that involves marking adults and chicks with alphanumeric color bands and resighting them at breeding areas throughout the Northern Great Plains. This study will provide population demographic and dispersal information that will greatly inform decisions about management, conservation, and recovery of this species, as well as informing management of the Missouri River.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

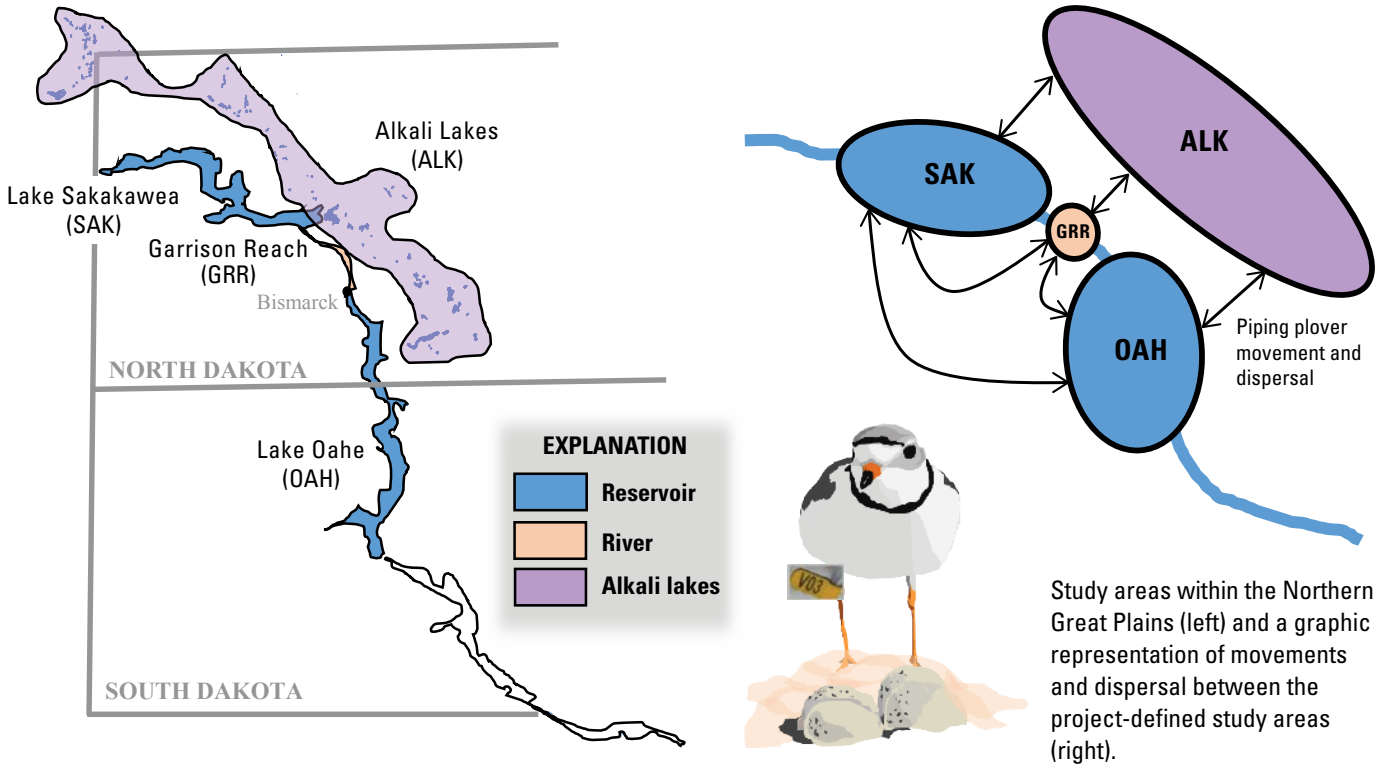
Collaborators: USACE, Omaha District, Threatened and Endangered Species Section; Missouri River Recovery Implementation Committee, FWS, North Dakota Ecological Services Field Office and Region 6 Refuge System; The Nature Conservancy

Products:

Roche, E.A., Dovichin, C.M., and Arnold, T.W., 2014, Field-readable alphanumeric flags are valuable markers for shorebirds—Use of double-marking to identify cases of misidentification: Journal of Field Ornithology, v. 85, no. 3, p. 329–338, https://doi.org/10.1111/jofo.12072.

Roche, E.A., Shaffer, T.L., Dovichin, C.M., Sherfy, M.H., Anteau, M.J., and Wiltermuth, M.T., 2016, Synchrony of piping plover breeding populations in the U.S. Northern Great Plains: The Condor, v. 118, no. 3, p. 558–570, https://doi.org/10.1650/CONDOR-15-195.1.

Toy, D.L., Roche, E.A., and Dovichin, C.M., 2017, Small high-definition video cameras as a tool to resight uniquely marked interior least terns (*Sternula antillarum athalassos*): Waterbirds, v. 40, no. 2, p. 180–186.



Study areas within the Northern Great Plains (left) and a graphic representation of movements and dispersal between the project-defined study areas (right).

16. Breeding Ecology and Demographics of Least Terns and Piping Plovers at the Central Platte River, Nebraska

U.S. Geological Survey field crew members nest searching for piping plover and least tern nests on a sandpit near the Central Platte River (U.S. Geological Survey photograph).

The Platte River Recovery Implementation Program (PRRIP) partnered with the NPWRC to study demographics of least terns and piping plovers at the Central Platte River in Nebraska. Because of water management and other alterations, riverine habitat for least terns and piping plovers has become degraded. Least terns and piping plovers, however, have begun breeding on sandpits that are immediately adjacent to the river. The NPWRC marked adults and chicks and resighted them to provide additional data for the PRRIP's monitoring practices. The NPWRC also analyzed data to provide information on dispersal, fidelity, and use of newly constructed or managed habitats that will be useful to make decisions to aid in the conservation and recovery of these species. In addition, the banding efforts along the Central Platte River have contributed to information for the NPWRC metapopulation study of piping plovers of the Northern Great Plains.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: PRRIP; Nebraska Public Power District; Nebraska Game and Parks Commission; Central Platte Natural Resources District, The Crane Trust

Products:

Roche, E.A., Sherfy, M.H., Ring, M.M., Shafter, T.L., Anteau, M.J., and Stucker, J.H., 2016, Demographics and movements of least terns and piping plovers in the Central Platte River Valley, Nebraska: U.S. Geological Survey Open-File Report 2016–1061, 27 p., https://doi.org/10.3133/ofr20161061.

17. Population Demographics of Least Terns and Piping Plovers in Colorado

Least tern and piping plover monitoring staff and U.S. Army Corps of Engineers staff observe piping plover nest on John Martin Reservoir. Photograph by Dustin Toy, U.S. Geological Survey.

The NPWRC is helping to improve the monitoring of federally listed least terns and piping plovers by the USACE at John Martin Reservoir in southeastern Colorado. The NPWRC is providing information to the USACE to improve their habitat management and productivity monitoring. The NPWRC is also providing the capability to mark adults and chicks with alphanumeric color bands over a 5-year period that began in 2017. The USACE's monitoring program will benefit from having the population of least terns and piping plovers that use this area uniquely marked because it will help them estimate recruitment and fidelity to breeding areas. Monitoring of marked birds at John Martin Reservoir as well as those marked elsewhere will answer broader questions about how isolated these populations are from other breeding areas. In addition, these banding efforts will contribute information for the NPWRC metapopulation study of piping plovers of the Northern Great Plains.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: USACE, Albuquerque District; Colorado Parks and Wildlife

18. Improving Monitoring Techniques for Nests of Interior Least Terns and Piping Plovers

Federally listed least terns and piping plovers are the subject of numerous large-scale population monitoring efforts that are used to assess needs and outcomes of management actions. Population monitoring requires periodic researcher visits to nesting areas to count and assess breeding status of the birds. At higher visit frequencies, detection of nests and chicks improves as does ability to determine outcomes of nesting attempts, resulting in more complete and accurate information about productivity; however, frequent visits may affect productivity of the birds by altering nest attendance or behavioral patterns. This study uses concealed miniature video cameras to (1) observe responses of nesting Missouri River least terns and piping plovers to human activities typically associated with population monitoring (that is, nest visits, adult trapping, chick banding); (2) evaluate accuracy of nest fate (success compared to failure) determined by field evidence obtained at various visitation frequencies; and (3) describe composition of the nest predator community on the Missouri River. Results of this study will aid management agencies in designing accurate population monitoring programs that minimize impacts on the birds, thereby improving quality of monitoring datasets and contributing to species recovery.

Nocturnal image of a great-horned owl depredating a least tern nest on the Missouri River. Photograph by Alicia Andes, University of North Dakota.

Contact: Mark H. Sherfy, msherfy@usgs.gov, 701–253–5504

Collaborators: FWS, North Dakota Ecological Services Field Office; USACE, Omaha District, Threatened and Endangered Species Section; University of North Dakota

19. Migration and Winter Ecology of the Aransas-Wood Buffalo Population of Whooping Cranes

The only self-sustaining population of endangered whooping cranes nests within and near Wood Buffalo National Park, Canada, migrates through the Great Plains and winters primarily along the Texas Gulf Coast. The objectives of this collaborative project are to address the entire annual life cycle of this species by advancing knowledge of breeding, wintering, and migration ecology, including threats to survival and population persistence. This research will allow us to identify potential barriers to species recovery. To complete this work, we have deployed and monitored 70 Global Positioning System (GPS)-enabled satellite transmitters during 2010–17. Through coordination of international capture teams and development of innovative trapping techniques, our efforts represent the first time adult whooping cranes have been successfully captured and marked. We also are characterizing stopover sites used by whooping cranes to document surrounding habitat characteristics and land-management practices to better define habitat criteria required by the species at stopover sites like the Platte River. Results from this project will inform recovery and management of whooping cranes into the foreseeable future.

A pair of whooping cranes walking along the edge of a wetland in central Kansas. The lead crane was marked with a satellite transmitter that collects multiple Global Positioning System locations per day. Photograph by Travis Wooten, U.S. Geological Survey.

Contact: Aaron T. Pearse, apearse@usgs.gov, 701–253–5509

Products:

Pearse, A.T., Harner, M.J., Baasch, D.M., Wright, G.D., Caven, A.J., and Metzger, K.L., 2017, Evaluation of nocturnal roost and diurnal sites used by whooping cranes in the Great Plains, United States: U.S. Geological Survey Open-File Report 2016–1209, 29 p., https://doi.org/10.3133/ofr20161209.

Pearse, A.T., Rabbe, M., Juliusson, L.M., Bidwell, M.T., Craig-Moore, L., Brandt, D.A., and Harrell, W., 2018, Delineating and identifying long-term changes in whooping crane (*Grus americana*) migration corridor: PLoS One, v. 13, no. 2, p. e0192737, https://doi.org/10.1371/journal.pone.0192737.

Collaborators: FWS, Regions 2 and 6; Canadian Wildlife Service; The Crane Trust; PRRIP; International Crane Foundation; Parks Canada

20. Understanding How Land-use Change in the Northern Great Plains Affects Pollinator Health and Pollination Services

Societal dependence on insects for pollination of agricultural crops has risen amidst concerns over global pollinator declines. Habitat loss and lack of forage have been implicated in the decline of managed and native pollinators in the United States. The NPWRC is conducting a regional research project to understand how land use affects honey bee colony health, and the economic revenue that beekeepers incur during the pollination season and when making new colonies the subsequent spring. Specifically, we are investigating how land use affects honey bee colony population size during the growing season (May–September), and if these impacts have subsequent influence on colony population size and survival for almond pollination in central California the following February. Our work highlights the downstream effects of factors driving land-use decisions on the ability of beekeepers to provide robust honey bee colonies to support the pollination industry on a national scale. It also demonstrates the direct linkages among grassland habitat in the Northern Great Plains, bee health, and pollination services rendered elsewhere in the United States.

A researcher conducts a health assessment on a honey bee colony in North Dakota. Photograph by Katie Lee, U.S. Geological Survey.

Contact: Clint R.V. Otto, cotto@usgs.gov, 701–253–5563

Products:

Spivak, M.S., Browning, Z., Goblirsch, M., Lee, K., Otto, C.R.V., Smart, M.D., and Wu-Smart, J., 2017, Why does bee health matter? The science surrounding honey bee concerns and what we can do about it: Council of Agricultural Science and Technology, QTA2017-1, http://www.cast-science.org/download.cfm?PublicationID=284638&File=04D683E8047DBC6EF36CE886CF73C70F.cfusion.]

U.S. Geological Survey, 2016, USGS pollinator research and monitoring [Clint Otto, videographer]: U.S. Geological Survey video, 00:05:02, https://www.youtube.com/watch?v=3_O6RDdrfDc.

Collaborators: USDA, Farm Service Agency and Natural Resources Conservation Service; Bee and Butterfly Habitat Fund; Project Apis m

21. Improving Forage for Honey Bees and Native Pollinators on Federal Conservation Lands

Honey bee laden with pollen. The Northern Prairie Wildlife Research Center has developed a genetic sequencing strategy to identify bee-collected pollen. Photograph by Sarah Scott, U.S. Geological Survey.

Since its inception in 1933, the U.S. Farm Bill has been one of the most influential Federal policies for agriculture and food production. Provisions within the Farm Bill have profound influence on global trade, nutrition programs, commodity crop programs, rural communities, and land conservation. The NPWRC's research quantifies the impact on pollinator forage and health of USDA conservation programs provisioned through the Farm Bill. We also are working with our USDA partners to evaluate conservation seeding mixes with potential to improve pollinator health in the Great Plains and upper Midwest, if included in programs such as the CRP. To address partner research needs, we have developed a novel technique using genetic sequencing to identify pollen collected from the bodies of foraging bees. Our work is designed to inform national policy decisions and assist with conservation planning across multiple states in the central United States.

Contact: Clint R.V. Otto, cotto@usgs.gov, 701–253–5563

Products:

Smart, M.D., Cornman, R.S., Iwanowicz, D.D., McDermott-Kubeczko, M., Pettis, J.S., Spivak, M.S., and Otto, C.R.V., 2017, A comparison of honey bee-collected pollen from working agricultural lands using light microscopy and ITS metabarcoding: Environmental Entomology, v. 46, no. 1, p. 38–49, https://doi.org/10.1093/ee/nvw159.

Collaborators: USDA, Farm Service Agency, Natural Resources Conservation Service, and Agricultural Research Service

22. Long-term Changes in Pollinator Resources (Alfalfa, Sweetclover, Milkweed) and Monarch Butterfly Populations in CRP Grasslands

Adult monarch butterfly feeding on an alfalfa plant in a Conservation Reserve Program grassland in Grant County, Minnesota. Photograph by Lawrence D. Igl, U.S. Geological Survey.

Project: Federal cropland retirement programs are increasingly being used to provide resources for pollinators (for example, nectar, pollen, host plants). Pollinator-friendly plant species (for example, alfalfa, sweetclover) were readily included in seed mixes in CRP grasslands since its inception in the 1985 Farm Bill. Through time, some native plant species (for example, milkweeds) also colonized CRP grasslands. Since the mid-1990s, the NPWRC has been quantifying changes in pollinator resources (alfalfa, sweetclover, and milkweed) and monarch butterfly abundance in several hundred CRP grasslands in nine counties in the Northern Great Plains. Understanding the long-term persistence, increase, or decline of monarchs and pollinator resources in CRP grasslands will help inform the design and management of current and future long-term cropland retirement programs.

Contact: Lawrence D. Igl, ligl@usgs.gov, 701–253–5511

Collaborators: Private Landowners, USDA, Farm Service Agency and Natural Resources Conservation Service

23. To Control or Not To Control—Response of Pollinator Communities To Invasive Plant Management

If invasive plants are producing pollen and nectar used by native pollinators, what happens when a manager decides to control the invasive plant? The NPWRC is addressing this question and has determined that pollinators are adept at changing their resource acquisition strategies as abundantly flowering invasive species decline. In addition, it seems that the invasive species in some cases may be drawing in additional pollinators, which then visit native plants as the invasive senesces. From the pollinators' perspective, the key consideration is that alternative resources are available, and from the manager's perspective, those resources should be the desired plant community. Information gained from this effort will allow land managers to be more fully informed when faced with the need to make decisions related to the control of invasive plants.

A Sphecid wasp nectaring on Canada thistle. Photograph by Diane L. Larson, U.S. Geological Survey.

Contact: Diane L. Larson, dlarson@usgs.gov, 651–649–5041

Products:

Larson, D.L., Rabie, P.A., Droege, S., Larson, J.L., and Haar, M., 2016, Exotic plant infestation is associated with decreased modularity and increased numbers of connectors in mixed-grass prairie pollination networks: PLoS One, v. 11, no. 5, p. e0155068, https://doi.org/10.1371/journal.pone.0155068.

Larson, D.L., Rabie, P.A., Droege, S., Larson, J.L., and Haar, M., 2016, Exotic plant infestation is associated with decreased modularity and increased numbers of connectors in mixed-grass prairie pollination networks: U.S. Geological Survey data release, https://doi.org/10.5066/F7H1302N

Collaborators: National Park Service, Badlands National Park

24. The Pollinator Library—A Decision-support Tool for Improving National Pollinator Conservation Efforts

Pollinator declines have emphasized the need for a greater understanding of plant-pollinator networks and land-management activities that improve pollinator habitat. At the request of USDA and FWS partners, the NPWRC created the Pollinator Library (https://www.npwrc.usgs.gov/pollinator/) for managers and researchers interested in improving pollinator forage on Federal and private lands. The aim of the Pollinator Library, which was created and is managed at the center, is to support management and research of plant-pollinator systems by documenting, synthesizing, and disseminating information on flowers that are used by pollinators and other insects. By providing free access to essential information, the Pollinator Library facilitates a better understanding of the foraging and habitat needs of flower-visiting insects and plant-pollinator systems. Currently, the Pollinator Library hosts records of about 27,000 pollinator and host plant interactions, including records from 13 States.

A native brown-belted bumble bee (*Bombus griseocollis*) visiting leadplant (*Amorpha canescens*). This photograph, and other plant-pollinator interaction photographs, are available on the Pollinator Library website. Photograph by Russ Bryant, U.S. Geological Survey.

Contact: Clint R.V. Otto, cotto@usgs.gov, 701–253–5563

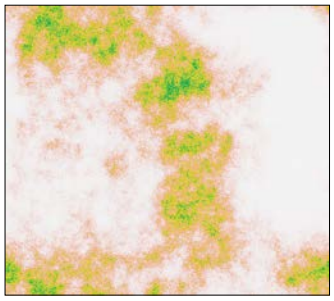
Products:

U.S. Geological Survey, 2018, The pollinator library: U.S. Geological Survey database, https://www.npwrc.usgs.gov/pollinator/.

Otto, C., O'Dell, S., Bryant, R., Euliss, N., Jr., Bush, R., and Smart, M., 2017, Using publicly available data to quantify plant-pollinator interactions and evaluate conservation seeding mixes in the Northern Great Plains: Environmental Entomology, v. 46, no. 3, p. 565–578, https://doi.org/10.1093/ee/nvx070.

Collaborators: FWS; USDA, Farm Service Agency and Natural Resources Conservation Service; Bee and Butterfly Habitat Fund

25. Developing a Sampling and Modeling Framework to Support Dakota Skipper Management Decisions



Predictive map of Dakota skippers based on historical observations.

The presence or absence of an endangered species on the landscape can have significant policy implications for public land managers and private landowners. The Dakota skipper, a grassland dependent butterfly, was listed in 2014 as a threatened species under the Endangered Species Act. This listing has created controversy in the states of North and South Dakota because of the potential regulatory impacts on private landowners, especially ranchers. The FWS would like to develop information about the current distribution of Dakota skippers to inform their conservation planning and management actions with regard to this species. The NPWRC is developing cutting edge quantitative tools to develop distribution maps for Dakota skippers based on past observations and studies. These maps will be used to develop a rigorous sampling strategy for further improving knowledge on abundance and distribution of Dakota skippers in the Northern Great Plains.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov, 701–253–5574

Collaborators: FWS, Region 6 Division of Biological Resources

26. Superior National Forest Wolf Population Trajectory

Radio-collared wolves are aerially tracked and the numbers of their packmates are counted annually. Photograph by L. David Mech, U.S. Geological Survey.

When the wolf was listed as endangered in the contiguous 48 States, the last remaining mainland wolf population was centered in the Superior National Forest of northeastern Minnesota. Since then, using aerial and GPS collar radio tracking, we have studied the wolf population trend, the factors influencing it, and the prey species (white-tailed deer and moose) affected by it. Wolf densities in the Superior National Forest have fluctuated between 1 per 8 square miles and 1 per 27 square miles (1 per 21 square kilometers and 1 per 69 square kilometers). Knowledge of these extreme fluctuations in this natural, protected population provides insight valuable to State and Federal resource managers charged with managing recovered and recovering wolf populations. For several years, this wolf population was subject to the emerging disease, canine parvovirus, which is fatal to pups, but gained resistance to it. Other diseases that these wolves were subject to, but apparently not negatively affected by, were Lyme disease and West Nile virus, which also infect humans. Wolves have also been implicated in a recent decline of the northeastern Minnesota moose population, primarily through their effects on calf survival.

Contact: L. David Mech, david_mech@usgs.gov, 651–649–5231

Products

Mech, L.D., 2016, Patuxent's long term research on wolves, *in* Perry, M.C., ed., The history of Patuxent—America's wildlife research story: U.S. Geological Survey Circular 1422, p. 197–211, https://doi.org/10.3133/cir1422.

Mech, L.D., Barber-Meyer, S.M., and Erb, J., 2016, Wolf (*Canis lupus*) generation time and proportion of current breeding females by age: PLoS One, v. 11, no. 6, p. e0156682, https://doi.org/10.1371/journal.pone.0156682.

Barber-Meyer, S.M., Mech, L.D., Newton, W., and Borg, B., 2016, Differential wolf-pack-size persistence and the role of risk when hunting dangerous prey: Behaviour, v. 153, no. 12, p. 1473–1487, https://doi.org/10.1163/1568539X-00003391.

Barber-Meyer, S.M., and Mech, L.D., 2016, White-tailed deer (*Odocoileus virginianus*) subsidize gray wolves during a moose (*Alces americanus*) decline—A case of apparent competition?: Canadian Field Naturalist, v. 130, no. 4, p. 308–314, https://doi.org/10.22621/cfn.v130i4.1924.

Mech, L.D., 2017, Where can wolves live and how can we live with them?: Biological Conservation, v. 210, p. 310–317, https://doi.org/10.1016/j.biocon.2017.04.029.

Carstensen, M., Giudice, J.H., Hildebrand, E.C., Dubey, J.P., Erb, J., Stark, D., Hart, J., Barber-Meyer, S.M., Mech, L.D., Windels, S., and Edwards, A.J., 2017, A serosurvey of diseases of free-ranging gray wolves (*Canis lupus*) in Minnesota, USA: Journal of Wildlife Diseases, v. 53, no. 3, p. 459–471, https://doi.org/10.7589/2016-06-140.

Barber-Meyer, S.M., Schmidt, L., and Mech, L.D., 2017, Gray wolf (*Canis lupus*) death by stick impalement: Northeastern Naturalist, v. 24, no. 2, p. N11–N14, https://doi.org/10.1656/045.024.0207.

Mech, L.D., and Barber-Meyer, S.M., 2017, Seasonality of intraspecific mortality by gray wolves: Journal of Mammalogy, v. 98, no. 6, p. 1538–1546, https://doi.org/10.1093/jmammal/gyx113.

Mech, L.D., Fieberg, J., and Barber-Meyer, S.M., 2018, An historical overview and update of wolf-moose interactions in northeastern Minnesota: Wildlife Society Bulletin, v. 42, no. 1, p. 40–47, https://doi.org/10.1002/wsb.844.

Collaborators: U.S. Forest Service, Superior National Forest; Minnesota Department of Natural Resources, Northeastern Region

27. Yellowstone Wolf Restoration

The National Park Service and FWS reintroduced wolves into Yellowstone National Park in 1995 and 1996. This study helps assess that population's recovery and determine factors that affect the population, including diseases, intraspecific strife, and interactions with prey. The restoration has been very successful, and the population has persisted for more than 20 years despite it being affected by canine distemper, mange, and other diseases. The most important mortality factor has been intraspecific strife (that is, wolves killing each other), almost always wolves from one pack killing members of other packs. Pack winners in these fights tend to be significantly larger, include significantly more males, and significantly more older males. This type of mortality is clearly inherent in wolf populations and results from breeding competition and perhaps competition for resources.

Contact: L. David Mech, david_mech@usgs.gov, 651–649–5231

The most important wolf mortality factor is being killed by other wolves. Photograph by L. David Mech, U.S. Geological Survey.

Products:

Cassidy, K.A., Smith, D.W., Mech, L.D., MacNulty, D.R., Stahler, D.R., and Metz, M.C., 2016, Territoriality and inter-pack aggression in gray wolves—Shaping a social carnivore's life history: Yellowstone Science, v. 24, no. 1, p. 37–42.

Cassidy, K.A., Mech, L.D., MacNulty, D.R., Stahler, D.R., and Smith, D.W., 2017, Sexually dimorphic aggression indicates male gray wolves specialize in pack defense against conspecific groups: Behavioural Processes, v. 136, p. 64–72, https://doi.org/10.1016/j.beproc.2017.01.011.

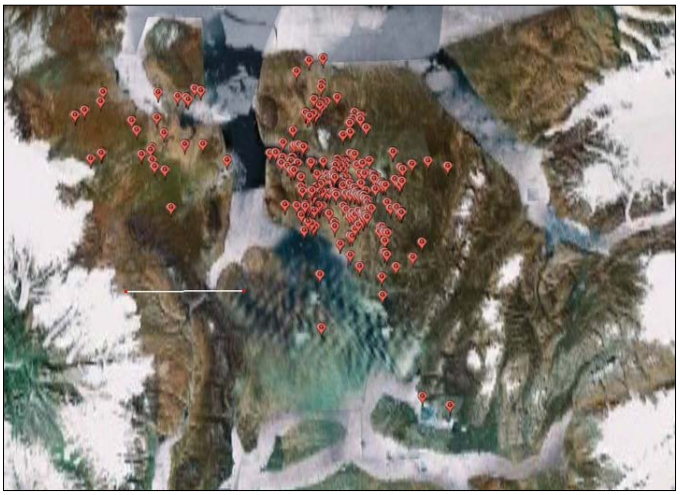
Allen, B.L., Allen, L.R., Andrén, H., Ballard, G., Boitani, L., Engeman, R.M., Fleming, P.J.S., Ford, A.T., Haswell, P.M., Kowalczyk, R., Linnell, J.D.C., Mech, L.D., and Parker, D.M., 2017, Can we save large carnivores without losing large carnivore science?: Food Webs, v. 12, p. 64–75, https://doi.org/10.1016/j.fooweb.2017.02.008.

Mech, L.D., and Barber-Meyer, S.M., 2017, Seasonality of intraspecific mortality by gray wolves: Journal of Mammalogy, v. 98, no. 6, p. 1538–1546, https://doi.org/10.1093/jmammal/gyx113.

Allen, B.L., Allen, L.R., Andrén, H., Ballard, G., Boitani, L., Engeman, R.M., Fleming, P.J.S., Ford, A.T., Haswell, P.M., Kowalczyk, R., Linnell, J.D.C., Mech, L.D., and Parker, D.M., 2017, Large carnivore science—Non-experimental studies are useful, but experiments are better: Food Webs, v. 13, p. 49–50, https://doi.org/10.1016/j.fooweb.2017.06.002.

Collaborators: National Park Service, Yellowstone National Park; University of Minnesota, Department of Fisheries, Wildlife and Conservation Biology

28. Ellesmere Wolf Movements



Example of winter movement data for a pack of 20 wolves on Ellesmere Island.

Wolves on Ellesmere Island, just south of the North Pole, survive in extreme cold during 24 hours of darkness per day from November through January, and survive in much higher temperatures during 24 hours of light per day from April through September. Determining the degree to which wolves are active, traveling, hunting, and resting provides insight into their general ability to adapt to various environmental factors. Partnering with other agencies, we use GPS radio collars applied to wolves during summer to examine wolf-pack movements on Ellesmere Island throughout the year. Through satellite-relayed data and wolf-pack sizes observed by weather station personnel, we can determine the year-round movements of wolf packs of various sizes. Clusters of wolf locations indicate potential kills of prey such as muskoxen (the wolves' primary food) and caribou. Packs of 20 or more wolves travel as much as 2,555 square miles (6,640 square kilometers) within territories during winter darkness and summer total light, make kills throughout the entire year, and produce litters averaging four pups each May.

Contact: L. David Mech, david_mech@usgs.gov, 651–649–5231

Products:

Mech, L.D., 2017, Extinguishing a learned response in a free-ranging gray wolf (*Canis lupus*): Canadian Field Naturalist, v. 131, no. 1, p. 23–25, https://doi.org/10.22621/cfn.v131i1.1951.

Collaborators: Utah State University, Wildland Resources Department; Wildlife Research Station, Nunavut Department of Environment; Northwest Territories Department of Environment and Natural Resources; Polar Continental Shelf Project; Eureka Weather Station, Environment Canada

29. Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota

Badlands National Park contains the largest contiguous bison range in the core of the species' historic range on the Northern Great Plains. The park nevertheless is too small to accommodate natural movements of free-ranging bison. As a result, historically intense-but-ephemeral effects of grazing by nomadic bison have been supplanted by somewhat consistent effects of grazing by resident bison. Furthermore, the herd is currently (2018) too small to prevent gradual loss of genetic diversity. Consequently, active management of bison abundance and distribution in the park is necessary to conserve the species and the natural processes in which it plays a keystone role. This research involves the use of satellite GPS collars to locate marked bison at hourly intervals throughout a 4-year period. Locations will be used to map the distribution of bison activity in the park and develop models relating intensities of use to features of landscapes, characteristics of vegetation, and proximity to water. Meanwhile, a companion project is assessing bison diets and the spatial distribution of productivity, composition, and consumption of park vegetation. Data resulting from these two studies will be used to explore the feasibility and compatibility of bison population and vegetation management objectives under various weather scenarios. Ultimately, results will be used by the National Park Service to refine and implement management strategies that benefit bison and native prairie vegetation at Badlands National Park.

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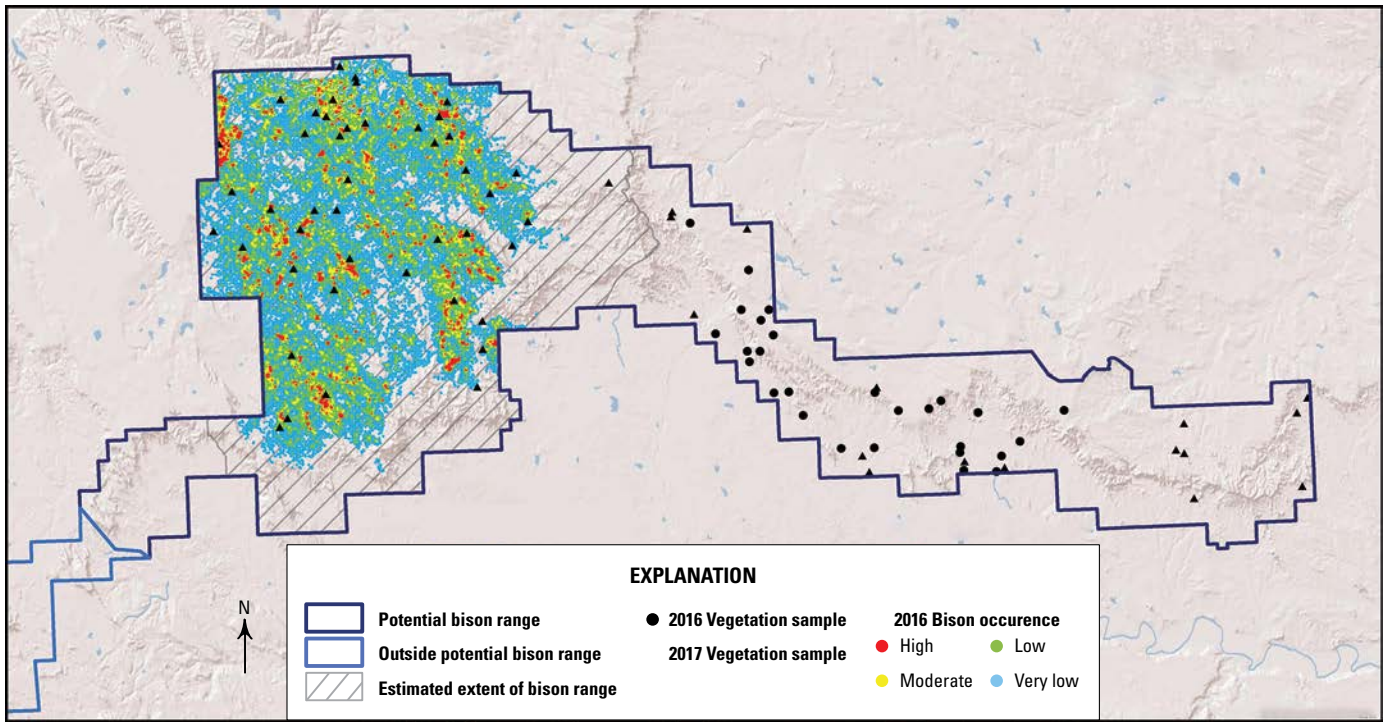
Collaborators: National Park Service, Badlands National Park



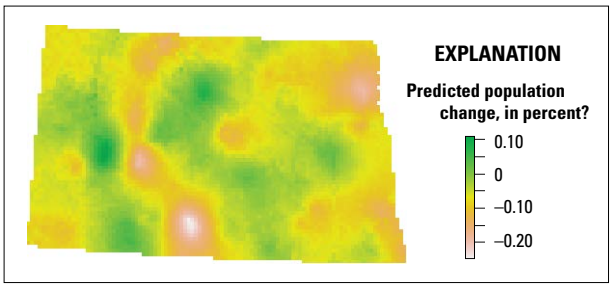
0 2 4 6 8 MILES
0 2 4 6 8 KILOMETERS

Preliminary data from global positioning system (GPS)-collared bison show the patchiness of bison use of their current range and that some parts of their expected range are inaccessible owing to topographical barriers. Vegetation sampling (to be continued in 2018) extends beyond the current bison range because Badlands National Park is in the process of adjusting fencing to increase the range and, consequently, population size.

Species Stressors

30. Spatiotemporal Dynamics of Grassland Songbird Populations in Response to Energy Development in an Agricultural Landscape

The recent expansion of unconventional oil and gas development in the Williston Basin of North America has raised concerns among managers about potential negative effects of such development on grassland birds. Others, however, have argued that agricultural land use in the region has had a much larger impact and that energy development may be a comparatively small stressor for grassland birds. Unfortunately, little information exists to help scientists and managers answer questions about the impact of energy development relative to the effects of widespread land conversion from agricultural production. To begin to answer these questions, we are using data from the BBS and quantitative spatial modeling techniques to assess population trends for various grassland bird species in the State of North Dakota, an area that historically had large tracts of grassland and has recently experienced an energy boom. We anticipate that our results will be useful in assessing the relative risks of various stressors and provide guidance to managers about where conservation should be invested on the landscape.



Predictive map of western meadowlark population trends in North Dakota.

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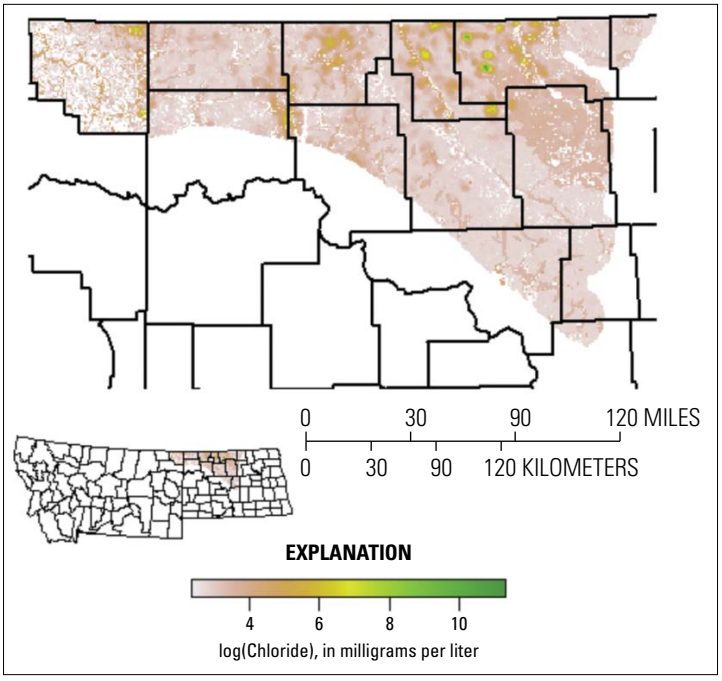
Collaborators: FWS

31. Monitoring and Modeling Wetland Chloride Concentrations in Relationship to Oil and Gas Development

Extraction of oil and gas by way of unconventional methods is becoming an important aspect of energy production worldwide. Studying the effects of this development in countries where these technologies are being widely used may provide managers in other oil producing parts of the world with some insight in terms of concerns associated with development. Rapid increases in energy development in North America have caught the attention of managers as a potential stressor on wildlife habitats. Among those concerns is the potential for brines associated with hydraulic fracking to impact water chemistry in wetlands. Using a landscape scale modeling approach, we examined relationships between chloride concentrations in wetlands and patterns of energy development. We anticipate these results will provide managers with ways to think about risks to wetlands from oil and gas development and provide them with a tool for prioritizing where to look for potential contamination on the landscape.



Predictive map of wetland chloride concentrations in the Prairie Pothole Portion of the Williston Basin.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov, 701–253–5574

Products:

Post van der Burg, M., and Tangen, B.A., 2015, Monitoring and modeling wetland chloride concentrations in relationship to oil and gas development: Journal of Environmental Management, v. 150, p. 120–127, https://doi.org/10.1016/j.jenvman.2014.10.028.

Collaborators: FWS, Region 6 National Wildlife Refuge System

32. Quantifying the Effects of Land-use Change and Bioenergy Crop Production on Ecosystem Services in the Northern Great Plains

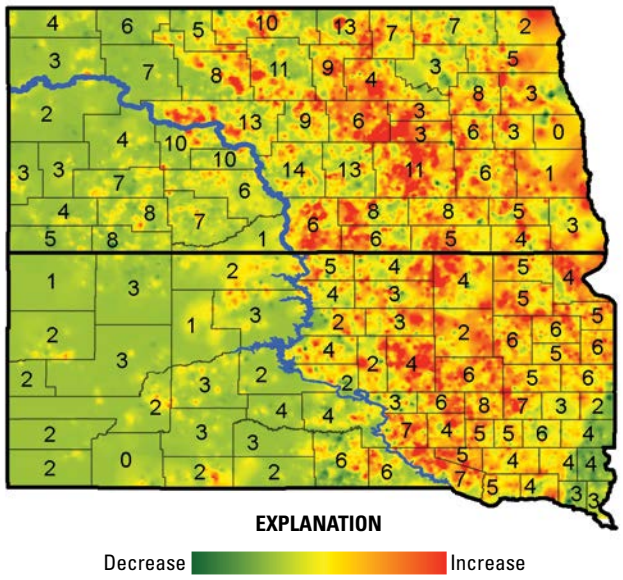
Rising commodity crop prices; increased Federal subsidies for biofuels, such as corn-based ethanol and soy-based biodiesel; and reduction in U.S. Farm Bill conservation programs have facilitated rapid land-use changes in the Northern Great Plains. Although renewable biofuels are touted as a mechanism for increasing energy security and potentially reducing greenhouse gas emissions, little is known about how rapid expansion of biofuel crops will impact ecosystem services. This research seeks to understand how land-use changes and biofuel crop development affect ecosystem services in the Northern Great Plains. For example, the NPWRC biofuels research team studies how land-use change and habitat alteration affect pollinator health and the ability of bees to pollinate agricultural crops. This research improves societal understanding of the downstream effects of land-use change and the ecological and economic tradeoffs associated with bioenergy crop production. The NPWRC biofuels research has been featured in more than 15 national and international media outlets since 2014.

Contact: Clint R.V. Otto, cotto@usgs.gov, 701–253–5563

Products:

Otto, C.R.V., Roth, C.L., Carlson, B.L., and Smart, M.D., 2016, Land-use change reduces habitat suitability for supporting managed honey bee colonies in the Northern Great Plains: Proceedings of the National Academy of Sciences of the United States of America, v. 113, no. 37, p. 10430–10435, https://doi.org/10.1073/pnas.1603481113.

Collaborators: USDA, Farm Service Agency and Natural Resources Conservation Service



Heat maps representing the annual rate of change in corn and soybean area around honey bee apiaries from 2006 to 2014. Maps were created using interpolation and data from 18,363 registered apiary locations in North and South Dakota. Red represents regions with the greatest annual increase of corn and soybean area surrounding commercial apiaries. Values within county boundaries represent the average number of registered apiaries per 10,000 hectares.

33. Assessment of Greenhouse Gas Fluxes from Wetland Catchments in the Prairie Pothole Region

Greenhouse gas fluxes and carbon cycling of prairie-pothole wetlands are not well understood, leading to high uncertainty in model estimates of these processes. Additionally, unprecedented changes to land use and land cover in the Northern Great Plains have the potential to alter the hydrology and water quality of wetland ecosystems, impacting greenhouse gas and carbon processes. Management, restoration, and protection efforts require that information gaps related to controls of these processes be addressed to refine model estimates and clarify biogeochemical processes of these wetlands to understand climate- and land-use-induced changes. Our focus is on the abiotic and biotic factors that regulate greenhouse gas fluxes and carbon sequestration to reduce uncertainties associated with temporal and spatial variability that characterizes these wetland systems. We examine these factors and processes intensively at a variety of sites throughout the Prairie Pothole Region to further our understanding of wetland response to changes in climate, hydrology, land use, and land management. Information gained will allow for the development of wetland conservation and management strategies that reduce greenhouse gas emissions and facilitate carbon storage.

Contact: Sheel Bansal, sbansal@usgs.gov, 701–253–5544

Products:

Bansal, S., Tangen, B.A., and Finocchiaro, R.G., 2016, Temperature and hydrology affect methane emissions from prairie pothole wetlands: Wetlands, v. 36, no. S2, suppl. 2, p. 371–381, https://doi.org/10.1007/s13157-016-0826-8.

Martins, P.D., Hoyt, D.W., Bansal, S., Mills, C.T., Tfaily, M., Tangen, B.A., Finocchiaro, R.G., Johnston, M.D., McAdams, B.C., Solensky, M.J., Smith, G.J., Chin, Y.P., and Wilkins, M.J., 2017, Abundant carbon substrates drive extremely high sulfate reduction rates and methane fluxes in prairie pothole wetlands: Global Change Biology, v. 23, no. 8, p. 3107–3120, https://doi.org/10.1111/gcb.13633.

Tangen, B.A., Finocchiaro, R.G., Gleason, R.A., and Dahl, C.F., 2016, Greenhouse gas fluxes of a shallow lake in south-central North Dakota, USA: Wetlands, v. 36, no. 4, p. 779–787, https://doi.org/10.1007/s13157-016-0782-3.

Bansal, S., and Tangen, B. A., 2016, Dissolved greenhouse gas concentrations and fluxes from Wetlands P7 and P8 of the Cottonwood Lake Study area, Stutsman County, North Dakota, 2015: U.S. Geological Survey data release, https://doi.org/10.5066/F7TX3CJ7.

Collaborators: U.S. Geological Survey, Crustal Geophysic & Geochemistry Science Center, National Research Program, and Woods Hole Coastal and Marine Science Center; FWS, Chase Lake Wetland Management District; U.S. Forest Service, Southern Research Station; USDA, Agricultural Research Service; Ohio State University; University of North Carolina, Chapel Hill; North Dakota State University, Carrington Research Extension Center and Microbial Sciences Department; Colorado State University; Ducks Unlimited, Inc.; Olympia Circuits

Technicians measuring greenhouse gas flux from floating chambers and water chemistry in a prairie pothole wetland at Cottonwood Lake Study Area, North Dakota (U.S. Geological Survey photograph).

34. Can Wetland Water-management Influence Mercury Bioaccumulation in Songbirds and Ducks at National Wildlife Refuges with Mercury Problems?

Photograph of a common yellowthroat, a wetland dependent songbird species captured so a small blood sample could be taken. Photograph by Lawrence D. Igl, U.S. Geological Survey.

During summer 2017, the NPWRC initiated a collaborative research study focused on understanding if water-level management of wetlands at refuges can affect mercury bioaccumulation in wetland-dependent migratory birds. Birds are susceptible to the effects of mercury and can serve as indicators of contamination in ecosystems. We examined mercury concentrations of songbirds and waterfowl using seven different management units at Kellys Slough National Wildlife Refuge near Grand Forks, North Dakota. A mercury hotspot had previously been reported in this area; our work is designed to investigate if four different water-management regimes potentially can affect mercury bioaccumulation. Preliminary analysis indicates that a wetland's management regime has profound implications for mercury bioaccumulation in migratory birds. We view this work as a case study that we wish to replicate in other public lands where mercury contamination is a concern. Ultimately, this work could have implications for water-level management of wetlands on public lands in areas where mercury may be a concern.

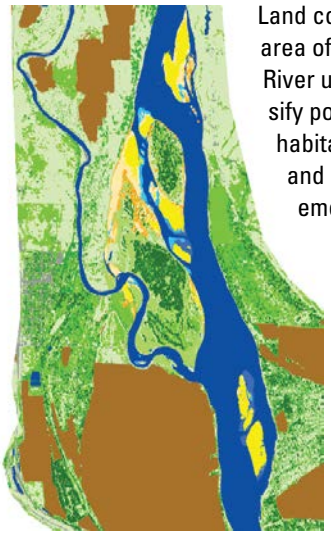
Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: USGS, Wisconsin Water Science Center and Western Ecological Research Center; FWS, National Wildlife Health Program and Devils Lake Wetland Management District, Benedictine College

Products:

Winder, V.L., Anteau, M.J., Fisher, M.R., Wilcox, M.K., Igl, L.D., and Ackerman, J.T., in press, Wetland water-management may influence mercury bioaccumulation in songbirds and ducks at a mercury hotspot: [Ecotoxicology invited *submission* for special issue]

35. Inventory, Mapping, Estimation, and Monitoring of Least Tern and Piping Plover Habitats on the Upper Missouri River Using Satellite Imagery



Land cover map of an area of the Missouri River used to classify potential breeding habitat for least terns and piping plovers on emergent sandbars.

Emergent sandbar maps of the Missouri River produced by the NPWRC continue to be used by the USACE and FWS to monitor and manage critical breeding habitat for the endangered Interior population of least terns and the threatened Northern Great Plains population of piping plovers. These maps have been created and refined annually for more than 10 years. Using high spatial resolution satellite imagery, we have developed and continue to refine a database of spectral and spatial properties of potential habitat categories that are classified using a probability-based method. During the past year, we have focused on increasing automation of these methods to further improve the cost-effectiveness of producing multiple maps during a season that capture temporal variability of available habitat on low-relief emergent sandbars that is related to variation in river discharge.

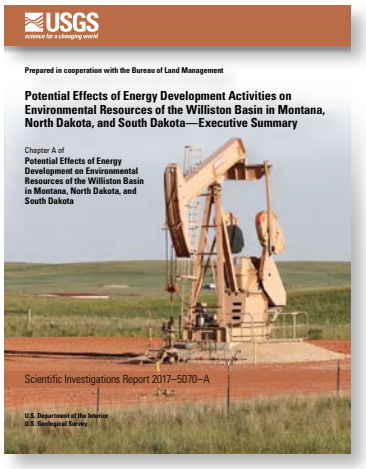
Contact: Mark T. Wiltermuth, mwiltermuth@usgs.gov, 701–253–5567

Collaborators: USACE, Omaha District, Threatened and Endangered Species Section

Management and Restoration

36. Potential Effects of Energy Development on Environmental Resources of the Williston Basin in Montana, North Dakota, and South Dakota

Federal resource managers in the Williston Basin need to understand how the recent expansion of oil and gas development is affecting a range of natural resources. The Bakken Federal Executive Group, a group of representatives from more than a dozen Federal and tribal agencies, called for a report that synthesizes existing information about the potential impacts from energy development. The Bakken Federal Executive Group recently partnered with the USGS to develop the report. The USGS used a two-phase approach to developing the report: (1) a decision-focused scoping process to narrow down informational topics; (2) assembling writing teams to assemble existing information. The final report consists of syntheses of the landscape and socioeconomic context of the energy boom, potential impacts of development on surface and groundwater, and potential impacts to wildlife and habitats. The information provided in this report is intended to assist with timely permitting decisions while providing information to assist in documenting potential impacts.



Cover of Scientific Investigations Report 2017–5070–D showing an oil well pump jack in a grassland in Stark County, North Dakota. Photograph by Lawrence D. Igl, U.S. Geological Survey.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov, 701–253–5574

Products:

Post van der Burg, M., Vining, K.C., Frankforter, J.D., eds., 2017, Potential effects of energy development on environmental resources of the Williston Basin in Montana, North Dakota, and South Dakota: U.S. Geological Survey Scientific Investigations Report 2017–5070–A–D, [variously paged], https://doi.org/10.3133/sir20175070.

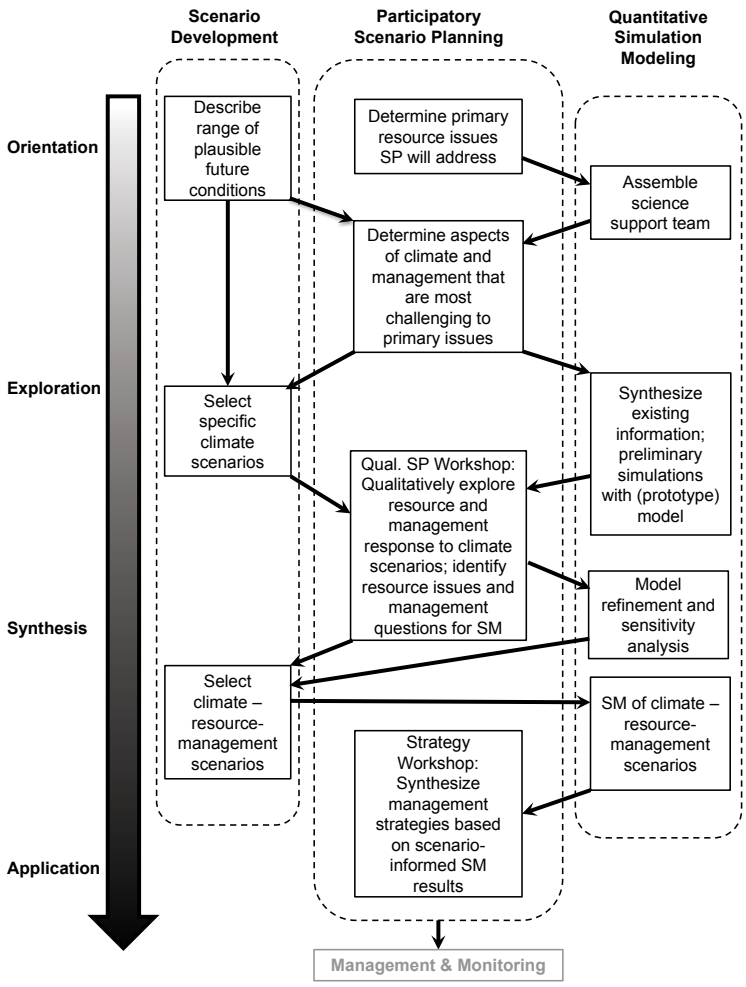
Post van der Burg, M., Symstad, A.J., Igl, L.D., Mushet, D.M., Larson, D.L., Sargeant, G.A., Harper, D.D., Farag, A.M., Tangen, B.A., and Anteau, M.J., 2017, Potential effects of energy development on environmental resources of the Williston Basin in Montana, North Dakota, and South Dakota—Species of conservation concern: U.S. Geological Survey Scientific Investigations Report 2017–5070–D, 41 p., https://doi.org/10.3133/sir20175070D.

Collaborators: Bureau of Land Management, Montana State Office; Bakken Federal Executive Group

37. Model-based Scenario Planning to Inform Climate Change Adaptation in the Northern Great Plains

Resource managers are tasked with managing complex systems with inherent uncertainty around how those systems might change with time and respond to management actions in a changing climate. Scenario planning—often implemented as a qualitative, participatory exercise for exploring multiple possible futures—is a valuable tool for addressing uncertainty. At the same time, quantitative information on projected climate changes and their impacts is rapidly growing and evolving, but this information is often not at a scale or in a form that resource managers can use. This project piloted a process for combining qualitative scenario planning and quantitative modeling in a way that would create manager-usable information, largely by emphasizing the coproduction of this information by scientists and managers. Building on this success, we are now streamlining the process to incorporate climate scenario planning into Resource Stewardship Strategies, a planning tool developed and used by the National Park Service across the Nation.

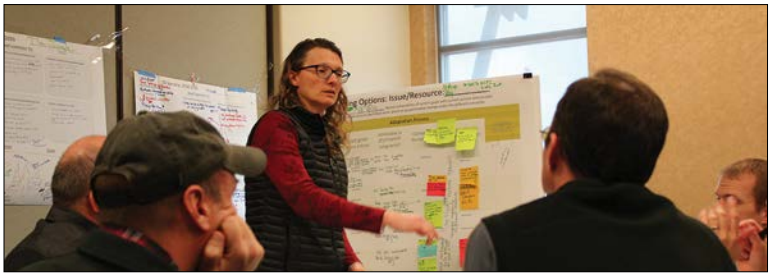
Contact: Amy J. Symstad, asymstad@usgs.gov, 605–745–1191



Scenario-based simulation modeling process developed to integrate management-appropriate quantitative modeling into climate change scenario planning for natural resources.

Source:

Symstad, A.J., Fisichelli, N.A., Miller, B.W., Rowland, E., and Schuurman, G.W., 2017, Multiple methods for multiple futures—Integrating qualitative scenario planning and quantitative simulation modeling for natural resource decision making: Climate Risk Management, v. 17, p. 78–91, https://doi.org/10.1016/j.crm.2017.07.002.



Participants in a scenario planning workshop for Badlands National Park and its surroundings discuss options for adapting management practices to four climate scenarios. Results of this discussion served as the basis for management alternatives explored in a followup quantitative simulation model. Photograph by National Park Service.

Products:

Fisichelli, N., Schuurman, G., Symstad, A., Ray, A., Friedman, J., Miller, B.W., and Rowland, E., 2016, Resource management and operations in central North Dakota: Climate change scenario planning workshop summary November 12–13, 2015, Bismarck, ND: Fort Collins, Colo., National Park Service, Natural Resource Report NPS/NRSS/NRR—2016/1262, 44 p., https://irma.nps.gov/DataStore/DownloadFile/554412.

Fisichelli, N., Schuurman, G., Symstad, A., Ray, A., Miller, B.W., Cross, M., and Rowland, E., 2016, Resource management and operations in southwest South Dakota: Climate change scenario planning workshop summary January 20–21, 2016, Rapid City, SD: Fort Collins, Colo., National Park Service, Natural Resource Report NPS/NRSS/NRR—2016/1289, 61 p., https://irma.nps.gov/DataStore/DownloadFile/554801.

Miller, B.W., Symstad, A.J., Frid, L., Fisichelli, N.A., and Schuurman, G.W., 2017, Co-producing simulation models to inform resource management—A case study from southwest South Dakota: Ecosphere, v. 8, no. 12, p. e02020, https://doi.org/10.1002/ecs2.2020.

Miller, B.W., Symstad, A.J., Frid, L., Fisichelli, N., and Schuurman, G.W., 2017, State-and-transition simulation model of rangeland vegetation in southwest South Dakota (1969–2050): U.S. Geological Survey data release, https://doi.org/10.5066/F7T1524X.

Symstad, A.J., Fisichelli, N.A., Miller, B.W., Rowland, E., and Schuurman, G.W., 2017, Multiple methods for multiple futures—Integrating qualitative scenario planning and quantitative simulation modeling for natural resource decision making: Climate Risk Management, v. 17, p. 78–91, https://doi.org/10.1016/j.crm.2017.07.002.

Collaborators: DOI North Central Climate Science Center; National Park Service, Badlands National Park, Knife River Indian Villages National Historic Site, Devils Tower National Monument, Climate Change Response Program, and Denver Service Center Planning Office; U.S. Forest Service, Buffalo Gap National Grassland; National Oceanic and Atmospheric Administration Earth System Research Lab, Physical Sciences Division; and Wildlife Conservation Society

38. USDA CRP Durability Assessment with Fort Collins Science Center

The NPWRC is assisting the Fort Collins Science Center with an assessment of the current status of agricultural lands that were previously enrolled in the USDA's CRP. The goal of this effort is to provide the USDA with information on the fate and condition of grasslands established under the program after the CRP contracts protecting those grasslands expire (for example, are they maintained as habitat, used for livestock grazing, or returned to crop production; and, of those that remain, what species do they support?). This study across 14 States in the central and western United States is designed to address these questions. We are assisting the Fort Collins Science Center by overseeing field sampling of CRP sites in North Dakota, South Dakota, and Minnesota. Information gained will used by the USDA and others to refine management actions and policy decisions regarding the long-term provisioning of wildlife habitat and other environmental services provided by perennial grasslands in agricultural landscapes.

Cattle grazing in a South Dakota grassland. Photograph by David M. Mushet, U.S. Geological Survey.

Contact: David M. Mushet, dmushet@usgs.gov, 701–253–5558

Collaborators: USGS, Fort Collins Science Center; USDA, Farm Service Agency

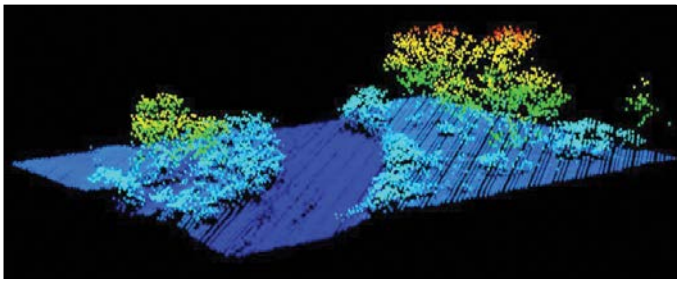
39. Improving Wildlife-habitat Modeling and Assessments with Light Detection and Ranging (lidar)

The NPWRC is assessing if the fine-scale three-dimensional point-cloud data generated from airborne lidar acquisitions can be summarized and quantified into useful metrics for improving empirical models relating wildlife to habitat. Lidar has proven itself as a valuable tool for providing high-resolution digital elevation models and for quantifying forest stand metrics utilized by the forest industry. Studies are only beginning to emerge relating lidar data directly to wildlife species occurrences and abundances. The NPWRC has been assessing capabilities of lidar data in various ecosystems to include the mixed forests in Maine and Minnesota, woodlots in North Dakota, sagebrush steppe in Wyoming, and riparian systems along the Central Platte River, Nebraska, as well as arid riparian areas in the Great Basin of Nevada. Improvement of the predictive ability of wildlife-habitat relationship models that utilize remote sensing technologies such as lidar, especially when combined with other remotely sensed images (for example, Landsat), should lead to better mapping of wildlife species occurrences and abundances, and thus better management decisions across broad landscapes.

Contact: Wesley E. Newton, wnewton@usgs.gov, 701–253–5523

Products:

Igl, L.D., Kantrud, H.A., and Newton, W.E., 2018, Bird population changes following the establishment of a diverse stand of woody plants in a former crop field in North Dakota—1975–2015: Great Plains Research, v. 28, no. 1, p. 73–90, https://doi.org/10.1353/gpr.2018.0006.



Point-cloud data illustrating the fine-scale three-dimensional structure provided by light detection and ranging (lidar).

Collaborators: USGS, Wyoming Landscape Conservation Initiative and Central Platte River Priority Ecosystem; FWS, Moosehorn National Wildlife Refuge; FWS, Lahontan National Fish Hatchery Complex; Minnesota National Guard, Camp Ripley

40. Impacts of Wind-turbine Energy Complexes on Northern Prairie Grouse

Wind energy in the Northern Great Plains is primarily developed along the Missouri Coteau and Missouri River Plateau in North Dakota and South Dakota. Although these areas rank high in wind-energy potential, they also contain important breeding habitat for sharp-tailed grouse and greater prairie-chickens. The impact of these wind-energy developments on prairie grouse populations and trends in the Northern Great Plains are largely unknown. Since 2003, the NPWRC has researched the impacts of wind-energy developments on breeding grassland birds, including sharp-tailed grouse and greater prairie-chickens. Using spring lek survey data collected by the NPWRC and existing grouse survey data provided by North Dakota Game and Fish and by South Dakota Game, Fish and Parks, the NPWRC is assessing if the various survey datasets can be combined, and if so, can they be used to assess the potential impacts wind-energy development might be having on grouse lek counts and trends at a landscape level.

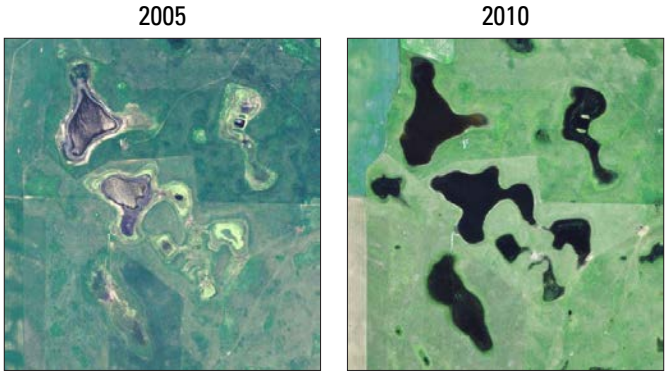
Male sharp-tailed grouse and male greater prairie-chicken during spring breeding season. Photograph by Rachel Bush, U.S. Geological Survey.

Contact: Wesley E. Newton, wnewton@usgs.gov, 701–253–5523

Collaborators: FWS, Ecological Services, North Dakota Field Office; North Dakota Game and Fish; South Dakota Game, Fish and Parks

41. Interaction of Land Use and Wet/Dry Cycles on Invertebrate Populations of Northern Prairie Wetlands—Implications for Waterbird Habitat Conservation

The NPWRC is completing a project aimed at understanding how productivity of larger and more permanent wetlands is affected by a combination of interannual hydrological dynamics and agricultural land-use impacts. Historically, productivity and abundance of aquatic invertebrates primarily was driven by interannual hydrological dynamics because drying periods allow for nutrient cycling and a subsequent pulse of productivity when wet conditions return. We examined aquatic macroinvertebrate abundance during a drying phase (when productivity is expected to be lowest) and during a rewetting phase (when productivity is expected to be greatest). We focused particularly on amphipod species because of their importance for ducks and their ability to indicate wetland quality. Our findings indicate that wetland quality has declined and those declines seem not to be attributable to hydrological dynamics of the Prairie Pothole landscape. This research was a companion study to "Interactions of consolidation drainage and climate on water-level dynamics, wetland productivity, and waterbirds," and together these reports help inform the effects of land-use change, climate, and invasive species on productivity of wetlands in the Prairie Pothole Region, and their value to migratory ducks.



Interannual water-level fluctuation between 2005 and 2010 within a complex of wetlands in Kidder County, North Dakota.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: FWS, Region 6 Refuges, Wetland Management Districts, and HAPET; Plains and Prairie Potholes Landscape Conservation Cooperative; Ducks Unlimited Inc.; Ducks Unlimited Canada; North Dakota Game and Fish Department; Louisiana State University; North Dakota State University

Products:

Anteau, M.J., Wiltermuth, M.T., Post van der Burg, M., and Pearse, A.T., 2016, Prerequisites for understanding climate-change impacts on northern prairie wetlands: Wetlands, v. 36, S2, p. 299–307, https://doi.org/10.1007/s13157-016-0811-2.

Wiltermuth, M.T., and Anteau, M.J., 2016, Is consolidation drainage an indirect mechanism for increased abundance of cattail in northern prairie wetlands?: Wetlands Ecology and Management, v. 24, no. 5, p. 533–544, https://doi.org/10.1007/s11273-016-9485-z.

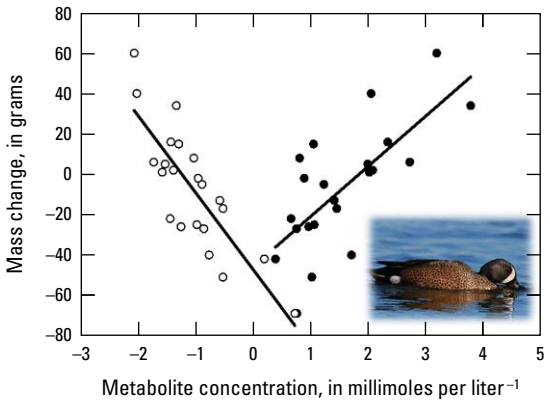
Wiltermuth, M.T., 2014, Influences of climate variability and landscape modifications on water dynamics, community structure, and amphipod populations in large prairie wetlands—Implications for waterbird conservation: Fargo, North Dakota, North Dakota State University, Ph.D. dissertation, https://pqdtopen.proquest.com/pubnum/3670216.html.

42. Evaluating Wetland-ecosystem Health Using Real-time Nutrient Dynamics of Ducks

The NPWRC leads a collaborative effort, spanning several studies, with the objective of improving techniques to assess the quality of spring migration habitat for ducks. Spring is a critical time in in the life cycle of migratory ducks because during migration they experience peak energetic needs at a time when food resources are often at their scarcest. Accordingly, ducks must maximize energy replenishment rates by eating high-lipid forage on spring stopover habitats. Our research is focused on assessing the quality of those stopover habitats and improving the techniques for those efforts. We are utilizing plasma-lipid metabolites of migratory ducks to assess their real-time refueling rates on spring stopover wetland habitats. This work is being done through three graduate students that are being coadvised at the NPWRC. The results will improve further research on spring stopover habitats and assess wetland ecosystem health on a broad scale to inform more efficient conservation efforts (for example, restoration and protection of wetland habitats).

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: USGS South Dakota Cooperative Fish and Wildlife Research Unit; The Mississippi Flyway Council; Illinois Department of Natural Resources; South Dakota Game Fish and Parks; South Dakota State University, Western Illinois University; Ducks Unlimited Canada; Forbes Biological Station; Illinois Natural History Survey



Relationships of two lipid metabolites (Triglycerides [shaded circles] and Beta-hydroxybutyrate [unshaded circles]) with 1-day mass changes in free living lesser scaup during spring migration (from Anteau and Afton, 2008). Photograph by Nick Smith, U.S. Geological Survey.

Products:

Janke, A.K., 2016, A physiological assessment of wetland habitats for spring-migrating ducks in the agricultural landscapes of the southern Prairie Pothole Region: Brookings, South Dakota, South Dakota State University, Ph.D. dissertation, https://openprairie.sdstate.edu/etd/677/.

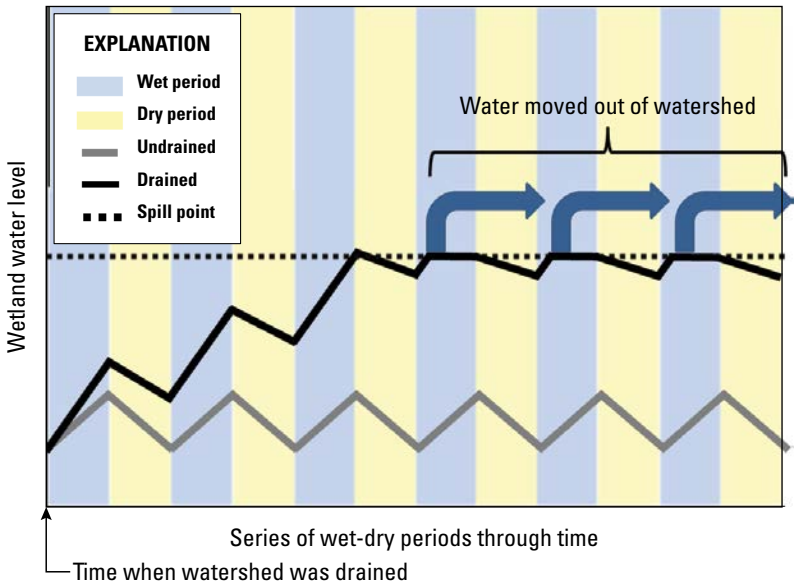
Janke, A.K., Anteau, M.J., Markl, N., and Stafford, J.D., 2015, Is income breeding an appropriate construct for waterfowl?: Journal of Ornithology, v. 156, no. 3, p. 755–762, https://doi.org/10.1007/s10336-015-1200-y.

43. Interactions of Consolidation Drainage and Climate on Water-level Dynamics, Wetland Productivity, and Waterbirds

The NPWRC recently completed a project aimed at understanding the impacts of wetland drainage on wetlands that receive drainage water. The biological communities of prairie-pothole wetlands evolved in a hydrologically dynamic system due to periodic wet and dry conditions. The NPWRC research indicates that relative to wetlands in undrained landscapes, wetlands that receive consolidation drainage water draw down less during dry conditions and progressively get larger and stabilize at their spill point during wet conditions. The implications of this water-level increase and eventual stabilization is that it reduces biological productivity and favors invasive species. These results have informed conservation efforts toward watershed-oriented restoration and protection of wetlands in the Prairie Pothole Region.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: FWS, Region 6 Refuges, Wetland Management Districts, and HAPET; Plains and Prairie Potholes Landscape Conservation Cooperative; South Dakota State University



Conceptual model that incorporates observed and theoretical relationships that describe the response of wetland water levels to climate variability in landscapes that are undrained landscapes or that have had extensive consolidation drainage (from Anteau and others 2016).

Products:

McCauley, L.A., and Anteau, M.J., 2014, Generating nested wetland catchments with readily-available digital elevation data may improve evaluations of land-use change on wetlands: Wetlands, v. 34, no. 6, p. 1123–1132, https://doi.org/10.1007/s13157-014-0571-9.

McCauley, L.A., Anteau, M.J., and Post van der Burg, M., 2016, Consolidation drainage and climate change may reduce Piping Plover habitat in the Great Plains: Journal of Fish and Wildlife Management, v. 7, no. 1, p. 4–13, https://doi.org/10.3996/072015-JFWM-068.

McCauley, L.A., Anteau, M.J., Post van der Burg, M., and Wiltermuth, M.T., 2015, Land use and wetland drainage affect water-level dynamics of remaining wetlands: Ecosphere, v. 6, no. 6, p. 1–22, https://doi.org/10.1890/ES14-00494.1.

Anteau, M.J., Wiltermuth, M.T., Post van der Burg, M., and Pearse, A.T., 2016, Prerequisites for understanding climate-change impacts on northern prairie wetlands: Wetlands, v. 36, S2, p. 299–307, https://doi.org/10.1007/s13157-016-0811-2.

Post van der Burg, M., Anteau, M.J., McCauley, L.A., and Wiltermuth, M.T., 2016, A Bayesian approach for temporally scaling climate for modeling ecological systems: Ecology and Evolution, v. 6, no. 9, p. 2978–2987, https://doi.org/10.1002/ece3.2092.

Wiltermuth, M.T., and Anteau, M.J., 2016, Is consolidation drainage an indirect mechanism for increased abundance of cattail in northern prairie wetlands?: Wetlands Ecology and Management, v. 24, no. 5, p. 533–544, https://doi.org/10.1007/s11273-016-9485-z.

44. Restoration of Wetland Invertebrates to Improve Wildlife Habitat in Minnesota

The NPWRC is investigating limitations to restoring abundant aquatic macroinvertebrate populations to Minnesota wetlands and shallow lakes. Recent research on larger, more permanent wetlands in Minnesota indicates that there have been decreases in quality of wetlands of use by ducks. That research also describes a decline in abundance of amphipods, a shrimp-like Crustacean. Amphipods are important forage for ducks during spring migration because they are nutritious and can occur at very high densities. This research is focused on understanding what factors limit super abundance of amphipods in Minnesota wetlands. The work will examine limitations of amphipod dispersal and factors that reduce wetland quality (for example, invasive species, agricultural effects). This study combines a large scale observational study with a field experiment that involves stocking amphipods. This project began during January 2018 and is funded through 2021.

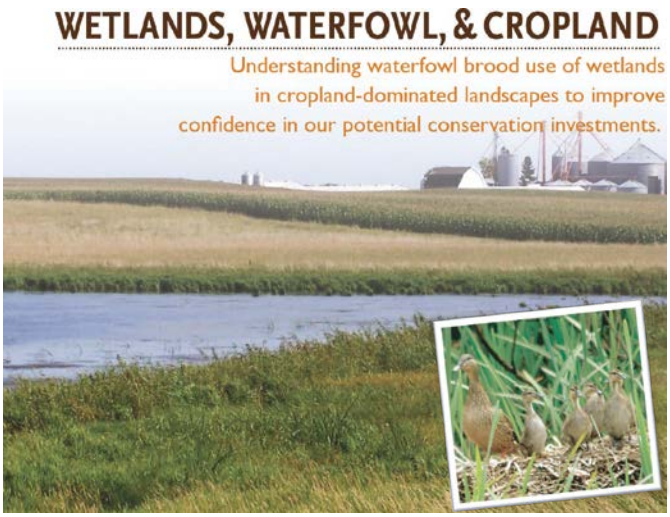
Amphipods collected during spring when pairs cling together for breeding. Photograph by Michael J. Anteau, U.S. Geological Survey.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: Minnesota Department of Natural Resources (lead agency), Bemidji State University, Environment and Natural Resources Trust Fund, Idaho State University, Legislative-Citizen Commission on Minnesota Resources, Lincoln Bait LCC

45. Importance of Wetlands in Intensively Farmed Landscapes to Duck Production

During 2017, the NPWRC began collaborating with a new partnership to investigate the role of intensively farmed landscapes of for production of ducks in the Prairie Pothole Region of the Northern Great Plains. The Prairie Pothole Region annually hosts 50–80 percent of North America's ducks during the breeding season. The Prairie Pothole Region ecosystem has a number of stressors, and intensive agriculture is chief among them. Accordingly, there are significant government and private funds that go to conservation for the purposes of improving duck production in the Prairie Pothole Region. The current conservation paradigm focuses on protection of habitat in less-farmed landscapes; however, restoration of habitats in intensively farmed landscapes may prove to be an equally valuable approach because areas that are intensively farmed often have a greater baseline capacity for biological productivity. Our research aims to evaluate tradeoffs of baseline productivity with potential negative agricultural effects on duck productivity, while exploring potential avenues to mitigate those negative effects. Our work will start with a pilot study in Iowa and Minnesota during summer 2018 and expand into North and South Dakota during 2019 and 2020. Ultimately, this work should help inform where conservation efforts may be most beneficial to ducks, allowing for future work to address social and economic issues associated with where and how conservation is applied to the Prairie Pothole Region landscape.



Mallard brood in a prairie wetland (foreground) and a wetland in an intensively farmed landscape (background). Photographs provided by Ducks Unlimited Inc.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: PPJV; Ducks Unlimited Inc. (lead agency); Iowa State University; Louisiana State University

46. Understanding Consequences of Management Strategies for Farmed Wetlands to Ecosystem Services in the Prairie Pothole Region

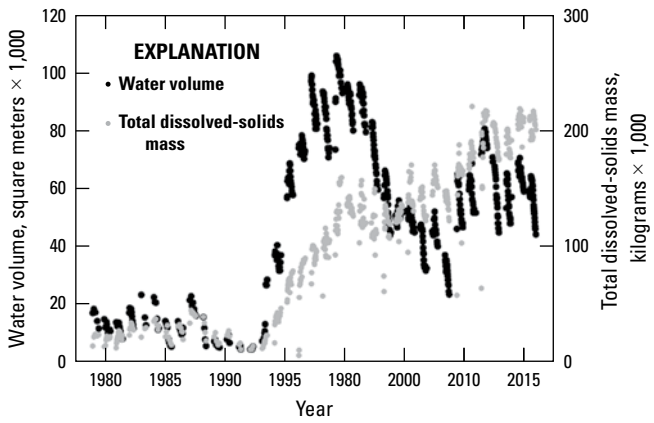
Waterfowl using a partially plowed wetland in an agricultural field. Photograph by Dustin L. Toy, U.S. Geological Survey.

The NPWRC is leading a partnership with North Dakota State University to examine ecological, social, and financial considerations of farming practices within temporarily ponded wetlands. Farmers strive to maximize crop production on their land and they may be more successful with more information on costs and benefits of certain management practices. There has been a long history of cropping prairie-pothole wetlands that are embedded within farm fields. For example, during dry falls, farmers often disturb or remove cattail within seasonal wetlands with hopes of planting crops in the wetlands during the subsequent spring. Wet conditions during spring or summer often prevent a harvestable yield from these areas; however, disturbance of these wetlands may be beneficial because wetlands choked with cattail provide little benefit for wildlife. Our findings will provide insights about ecological implications of wetland disturbance to migrating birds, profitability of farming wetlands, and farmer motivations in making land-use decisions about wetlands. We anticipate that this work will inform future experimental conservation practices whereby farmers may become more profitable and provide management actions to wetlands that benefit wildlife, particularly migratory waterbirds.

Contact: Michael J. Anteau, manteau@usgs.gov, 701–253–5507

Collaborators: North Dakota State University

47. A Systems Approach to Modeling Effects of Climate and Land-use Change on Prairie Wetland Ecosystems



Climate-induced shifts in water volume and mass of total dissolved solids that occurred in a semi-permanently ponded wetland of the Cottonwood Lake Study Area, Stutsman County, North Dakota, 1979–2015. Reproduced from McKenna and others, 2017.

The NPWRC is developing an integrated, process-based, systems model for prairie-pothole wetlands to facilitate forecasts of how climate and land-use change will affect wetland processes and biota. The Pothole Hydrology Linked System Simulator model (PHyLiSS) simulates changes in hydrology, water chemistry, plant communities, invertebrates, and other biota as a result of altered temperature and precipitation inputs. We use extensive biotic and abiotic datasets from the Missouri Coteau Wetland Ecosystem Observatory to parameterize, calibrate, and validate the model. Once completed, PHyLiSS will allow us to explore important scientific questions related to (1) how changes in climate will affect water levels and hydroperiods of prairie-pothole wetlands; (2) how these hydrological changes will affect chemical characteristics of various wetland types; (3) how plant communities, aquatic invertebrates, amphibians, waterfowl, and other biota will likely be affected; (4) how alternate land uses will interact with climate to alter wetland processes; and (5) how potential effects of climate change on prairie-wetland ecosystems might be mitigated. The answers to each of these questions will have direct implications to the conservation and management of these nationally important wetland ecosystems.

Contact: David M. Mushet, dmushet@usgs.gov, 701–253–5558

Products:

Mushet, D.M., 2016, Midcontinent prairie-pothole wetlands and climate change—An introduction to the supplement issue: Wetlands, v. 36, S2, p. 223–228, https://doi.org/10.1007/s13157-016-0852-6.

Goldhaber, M., Mills, C., Mushet, D.M., McCleskey, B., and Rover, J., 2016, Controls on the geochemical evolution of prairie pothole region wetlands over decadal time scales: Wetlands, v. 36, S2, p. 255–272, https://doi.org/10.1007/s13157-016-0854-4.

LaBaugh, J., Mushet, D.M., Rosenberry, D., Euliss, N.H., Jr., Goldhaber, M., Mills, C., and Nelson, R., 2016, Changes in pond water levels and surface extent due to climate variability alter solute sources to closed-basin prairie-pothole wetland ponds, 1979–2012: Wetlands, v. 36, S2, p. 343–355, https://doi.org/10.1007/s13157-016-0808-x.

Leibowitz, S., Mushet, D.M., and Newton, W.E., 2016, Intermittent surface water connectivity—Fill and spill vs. fill and merge dynamics: Wetlands, v. 36, S2, p. 323–342, https://doi.org/10.1007/s13157-016-0830-z.

van der Valk, A., and Mushet, D.M., 2016, Interannual water-level fluctuations and the vegetation of prairie potholes—Potential impacts of climate change: Wetlands, v. 36, S2, p. 397–406, https://doi.org/10.1007/s13157-016-0850-8.

McLean, K.I., Mushet, D.M., and Stockwell, C.A., 2016, From "duck factory" to "fish factory"—Climate induced changes in vertebrate communities of prairie pothole wetlands and small lakes: Wetlands, v. 36, S2, p. 407–421, https://doi.org/10.1007/s13157-016-0766-3.

McLean, K.I., Mushet, D.M., Renton, D., and Stockwell, C.A., 2016, Aquatic macro-invertebrate communities of prairie pothole lakes and wetlands under a changed climate: Wetlands, v. 36, S2, p. 423–435, https://doi.org/10.1007/s13157-016-0848-2.

Calhoun, A.J.K., Mushet, D.M., Bell, K.P., Boix, D., Fitzsimons, J.A., and Isselin-Nondedeu, F., 2016, Temporary wetlands—Challenges and solutions to conserving a 'disappearing' ecosystem: Biological Conservation, v. 211, p. 88–95, https://doi.org/10.1016/j.biocon.2016.11.024.

McKenna, O.P., Mushet, D.M., Rosenberry, D.O., and LaBaugh, J.W., 2017, Evidence for a climate-induced ecohydrological state shift in wetland ecosystems of the southern prairie pothole region: Climatic Change, v. 145, no. 3–4, p. 273–287, https://doi.org/10.1007/s10584-017-2097-7.

Collaborators: FWS, Chase Lake Wetland Management District; USDA, Natural Resources Conservation Service; North Dakota State University; University of North Dakota; University of Minnesota; The Ohio State University; Syracuse University

48. Development and Validation of Wetland-connectivity Indicators in the U.S. Prairie Pothole Region

We are working in partnership with the U.S. Environmental Protection Agency to (1) quantify cumulative effects of prairie-pothole wetlands on stream communities; (2) explore relationships between aquatic-system connectivity and genetic-, species-, and ecosystem-scale biological diversity at watershed and landscape scales; (3) develop mapping unit descriptors based on biotic community traits for ongoing hydrologic connectivity mapping efforts; and (4) facilitate data collection efforts associated with quantifications of watershed-scale hydrologic responses to the aggregate effects of prairie-pothole wetlands. This effort is also associated with a USGS Powell Center for Analysis and Synthesis effort to develop aquatic system hydrological- and biological-connectivity maps for the Nation. New to the effort in 2017 was development of a work-plan for exploring wetland effects on freshwater mussel communities in streams and cascading environmental effects in stream systems of mussel communities and associated "mussel beds" that are degraded or lost.

Contact: David M. Mushet, dmushet@usgs.gov, 701–253–5558

Wetlands in the Prairie Pothole Region of North America, while often appearing as isolated from each other, are interconnected through a variety of ways including temporary surface-water flows, long-term groundwater flows, and biotic movements. Photograph by David M. Mushet, U.S. Geological Survey.

Products:

Cohen, M.J., Creed, I.F., Alexander, L., Basu, N.B., Calhoun, A.J.K., Craft, C., D'Amico, E., DeKeyser, E.S., Fowler, L., Golden, H.E., Jawitz, J.W., Kalla, P., Kirkman, L.K., Lane, C.R., Lang, M., Leibowitz, S.G., Lewis, D.B., Marton, J., McLaughlin, D.L., Mushet, D.M., Raanan-Kiperwas, H., Rains, M.C., Smith, L., and Walls, S.C., 2016, Do geographically isolated wetlands influence landscape functions?: Proceedings of the National Academy of Sciences of the United States of America, v. 113, no. 8, p. 1978–1986, https://doi.org/10.1073/pnas.1512650113.

Mushet, D.M., Christensen, J., Bennett, M., and Alexander, L.C., 2017, Biota—Providing often-overlooked connections among freshwater systems: Water Resources Impact, v. 19, no. 2, p. 11–13.

Calhoun, A.J.K., Mushet, D.M., Alexander, M.J., DeKeyser, E.S., Fowler, L., Lane, C.R., Lang, M.W., Rains, M.C., Richter, S.C., and Walls, S.C., 2017, The significant surface-water connectivity of "geographically isolated wetlands": Wetlands, v. 37, no. 4, p. 801–806, https://doi.org/10.1007/s13157-017-0887-3.

Collaborators: U.S. Environmental Protection Agency, Office of Research and Development

49. Assessment of Pattern Tile Drainage on Wetland Hydrology and Ecosystem Services in the Prairie Pothole Region

Prairie Pothole Region wetlands provide numerous ecological services to society such as wildlife habitat, water storage, and carbon sequestration. Agricultural production in the region has been enhanced through the expanded installation and use of subsurface drainage systems, but these systems may have a negative impact on the region's wetlands, including those protected by conservation easements. We developed spatial databases of drainage system locations to provide a picture of areas that are being targeted for drainage and to identify landscape characteristics that are driving this practice. We also conducted a novel field study to examine potential effects of subsurface drainage systems on wetland hydrology, and the effectiveness of drainage system buffers for protecting wetlands. This work directly supports decision making and conservation efforts aimed at protecting and enhancing vital wetland habitats in the Prairie Pothole Region.

Contact: Brian A. Tangen, btangen@usgs.gov, 701–320–7698

Drainage pipe being installed in wetland catchment. Photograph by Charles Dahl, U.S. Geological Survey.

Products:

Finocchiaro, R.G., 2014, Agricultural subsurface drainage tile locations by permits in South Dakota: U.S. Geological Survey data release, http://dx.doi.org/10.5066/F7KS6PNW.

Finocchiaro, R.G., 2016, Agricultural subsurface drainage tile locations by permits in North Dakota: U.S. Geological Survey data release, http://dx.doi.org/10.5066/F7QF8QZW.

Tangen, B.A., and Finocchiaro, R.G., 2017, A case study examining the efficacy of drainage setbacks for limiting effects to wetlands in the Prairie Pothole Region, USA: Journal of Fish and Wildlife Management, v. 8, no. 2, p. 513–529, https://doi.org/10.3996/022017-JFWM-012.

Collaborators: FWS, Chase Lake National Wildlife Refuge; Plains and Prairie Potholes Landscape Conservation Cooperative; U.S. Environmental Protection Agency, Region 8; North Dakota Department of Health

50. Description of Aquatic Vegetation and Invertebrate Communities at Big Stone National Wildlife Refuge

Big Stone National Wildlife Refuge is situated within a riverine system where refuge wetlands receive sediment-laden inflows that have been associated with diminished plant communities and water-quality conditions. Accordingly, improved habitat- and water-quality conditions have been recognized as overall management goals, and the collection of baseline biotic and abiotic data has been identified as a priority to facilitate refuge planning, management, and restoration efforts. To support refuge management, we conducted a study with overall goals of characterizing the aquatic invertebrate and vegetation communities of the refuge and exploring relations between these communities and various water-quality parameters. Information provided by this study will directly support management of this and other refuges.

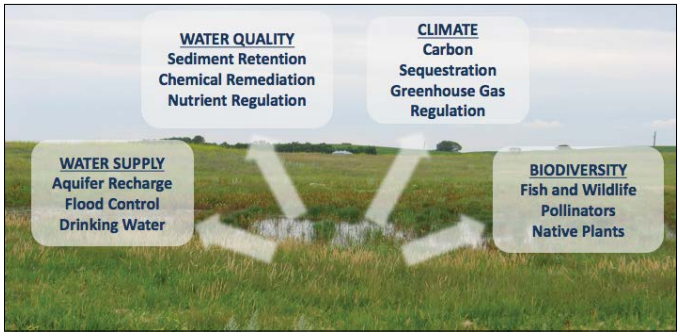
Contact: Brian A. Tangen, btangen@usgs.gov, 701–320–7698

Collaborators: FWS, Big Stone National Wildlife Refuge

Collecting aquatic invertebrates at Big Stone National Wildlife Refuge. Photograph by Charles Dahl, U.S. Geological Survey.

51. Quantify the Multiple Services Performed by Wetland Ecosystems in the U.S. Prairie Pothole Region

In response to the need to quantify wetland-ecosystem services as affected by Federal conservation programs, the NPWRC initiated an effort to develop an integrated landscape model that would facilitate the simultaneous evaluation of multiple services performed by prairie-pothole wetland ecosystems. This effort is focused on incorporating land-use and land-cover change into forecasting models that accounted for variations in agricultural practices and conservation programs. The primary tool being used in this effort is the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) modeling suite. We have parameterized this modeling tool for the Prairie Pothole Region of the United States and developed new components as needed to quantify conservation program and practice effects on wetland carbon stores; water quality; amphibian, waterfowl, and grassland-bird habitat; native-plant communities; and floral resources available to pollinators. We are also using a wetland systems model (PHyLiSS), developed under a separate project, to explore land-use change effects on depressional wetlands, and have expanded our reach beyond the Prairie Pothole Region to include work in the upper Mississippi River watershed. Model results are being used to inform implementation of conservation activities, such as practices conducted within the USDA CRP and Wetland Reserve Program, and policy making that affect wetland ecosystems throughout the agricultural landscape of the Northern Great Plains.



Wetlands perform multiple services valued by society that can be affected in various ways by conservation programs and practices. Photograph by David M. Mushet, U.S. Geological Survey.

Contact: David M. Mushet, dmushet@usgs.gov, 701–253–5558

Products:

Mushet, D.M., and Scherff, E.J., 2016, The integrated landscape modeling partnership—Current status and future directions (ver. 1.1, December 2016): U.S. Geological Survey Open-File Report 2016–1006, 59 p., https://doi.org/10.3133/ofr20161006.

Iovanna, R., Ando, A., Swinton, S., Kagan, J., Hellerstein, D., Rewa, C., Mushet, D., and Otto, C., 2017, The valuation of ecosystem services from farms and forests: Washington, DC, The Council on Food, Agricultural & Resource Economics, C-FARE Habitat Team Report, http://ageconsearch.umn.edu/record/260677/files/SynthesisChapter-TheValuationofEcosystemServicesfromFarmsandForests.pdf.

Williams, A.S., Kiniry, J.R., Mushet, D.M., Smith, L.M., McMurry, S., Attebury, K., Lang, M., McCarty, G.W., Shaffer, J.A., Effland, W.R., and Johnson, M.-V., 2017, Model parameters for representative wetland plant functional groups: Ecosphere, v. 8, no. 10, p. e01958, https://doi.org/10.1002/ecs2.1958.

Collaborators: USDA, Farm Service Agency Economics and Policy Analysis Staff, and Natural Resources Conservation Service

52. Quantifying Ecosystem Services Provided by Depressional Wetlands in the Upper Mississippi River

The NPWRC has conducted multiple research efforts related to developing methodology for quantifying the environmental and societal services provided by prairie-pothole wetland ecosystems. In this effort, we are exploring the feasibility of applying methodologies similar to those developed wetland ecosystems within the Prairie Pothole Region to other landscapes where depressional wetlands exist. One of those landscapes is the watershed of the upper Mississippi River. In this pilot effort, we are exploring the use of multiple models to quantify the effects of depressional wetlands in or adjacent to agricultural fields in a subwatershed of the upper Mississippi (that is, the Des Moines watershed) on reducing nutrient flows from croplands. We are also exploring the multiple effects of these cropland-embedded wetlands on the provisioning of habitat and other ecosystem services valued by society and how this additional information can be used in evaluations of nutrient flows to Mississippi River and ultimately Gulf of Mexico ecosystems.

Contact: David M. Mushet, dmushet@usgs.gov, 701–253–5558

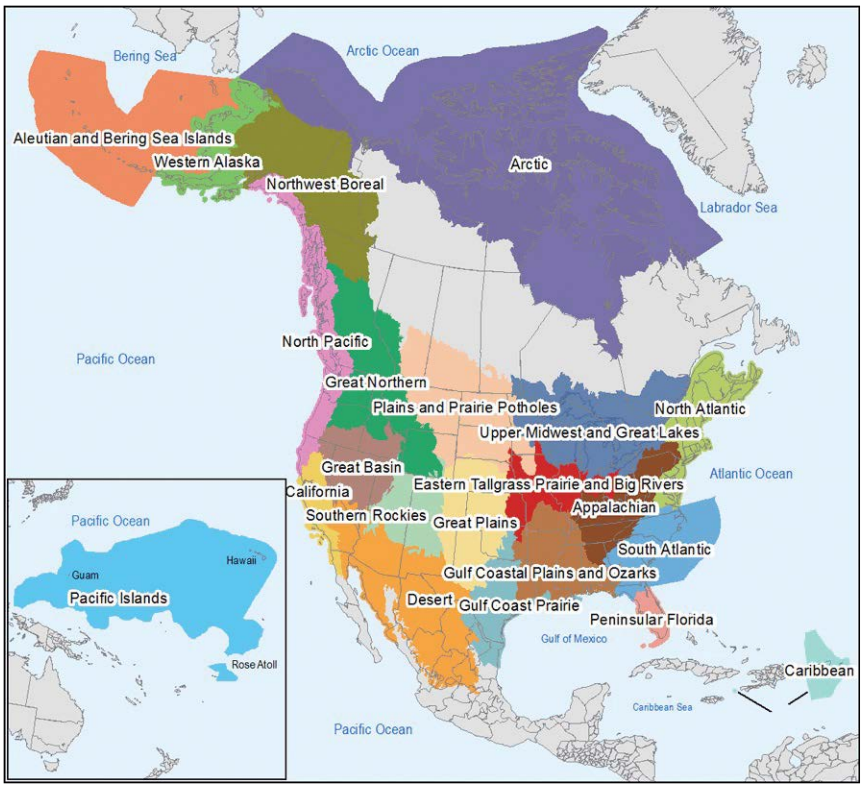
Collaborators: USGS

Depressional wetlands in croplands reduce nitrogen flows from fields in addition to performing other ecosystem services valuable to society. Photograph by David M. Mushet, U.S. Geological Survey.

53. Science Support for Landscape Conservation Cooperatives

Conservation practitioners have begun to realize that the many of the land-management challenges of the 21st century require a broad-scale problem solving approach. Landscape Conservation Cooperatives (LCCs) work to implement such an approach by serving as a venue for multiple conservation partners to work together (for example, Federal and State agencies), identify common problems, and support the development of science to better inform land-management decisions. The NPWRC has been supporting LCC partnerships in their goal to facilitate more effective responses to broad-scale conservation challenges since 2010. Although we have worked with multiple LCCs, our work has mainly been focused on the Plains and Prairie Potholes LCC. We have used decision analysis to structure and prioritize their science needs, conducted the research necessary to meet those needs, and used cutting edge analytical tools to support LCC strategic planning efforts.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov, 701–253–5574



Map of the Landscape Conservation Cooperative system (map credit: U.S. Fish and Wildlife Service).

Products:

Beever, E.A., Mattsson, B.J., Germino, M.J., Post van der Burg, M., Bradford, J.B., and Brunson, M.W., 2014, Successes and challenges from formation to implementation of eleven broad extent conservation programs: Conservation Biology, v. 28, no. 2, p. 302–314, https://doi.org/10.1111/cobi.12233.

McCauley, L.A., Anteau, M.J., Post van der Burg, M., and Wiltermuth, M.T., 2015, Land use and wetland drainage affect water levels and dynamics of remaining wetlands: Ecosphere, v. 6, p. 1–22, http://dx.doi.org/10.1890/ES14-00494.1.

Post van der Burg, M., Thomas, C.C., Holcombe, T., and Nelson, R.D., 2016, Benefits and limitations of using decision-analytic tools to assess uncertainty and prioritize Landscape Conservation Cooperative information needs: Journal of Fish and Wildlife Management, v. 7, no. 1, p. 280–290, https://doi.org/10.3996/032015-JFWM-023.

Collaborators: Plains and Prairie Potholes LCC and Eastern Tallgrass and Big Rivers LCC

54. Decision Analysis and Support

Natural resource decision makers face numerous challenges in terms of making choices to solve complex management problems. Many of these challenges stem from being overwhelmed by too many choices, uncertain or delayed outcomes, and multiple stakeholders with conflicting desires. Decision analysis (also known as structured decision making) is a set of qualitative and quantitative tools for structuring and analyzing the impediments to decision making, with a focus on overcoming those impediments. At the NPWRC, we use the principles of decision analysis, coupled with our expertise in ecological analysis, to help our partners make more transparent and defensible management decisions. Projects our center have supported range from finding optimal climate adaptation strategies for historical resources in the National Parks, helping the FWS find solutions to specific refuge management problems, and helping our partners identify the scientific information that is most important in their decisions. Our staff also participates in training and mentorship programs associated with National Conservation Training Center in Shepherdstown, West Virginia.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov, 701–253–5574

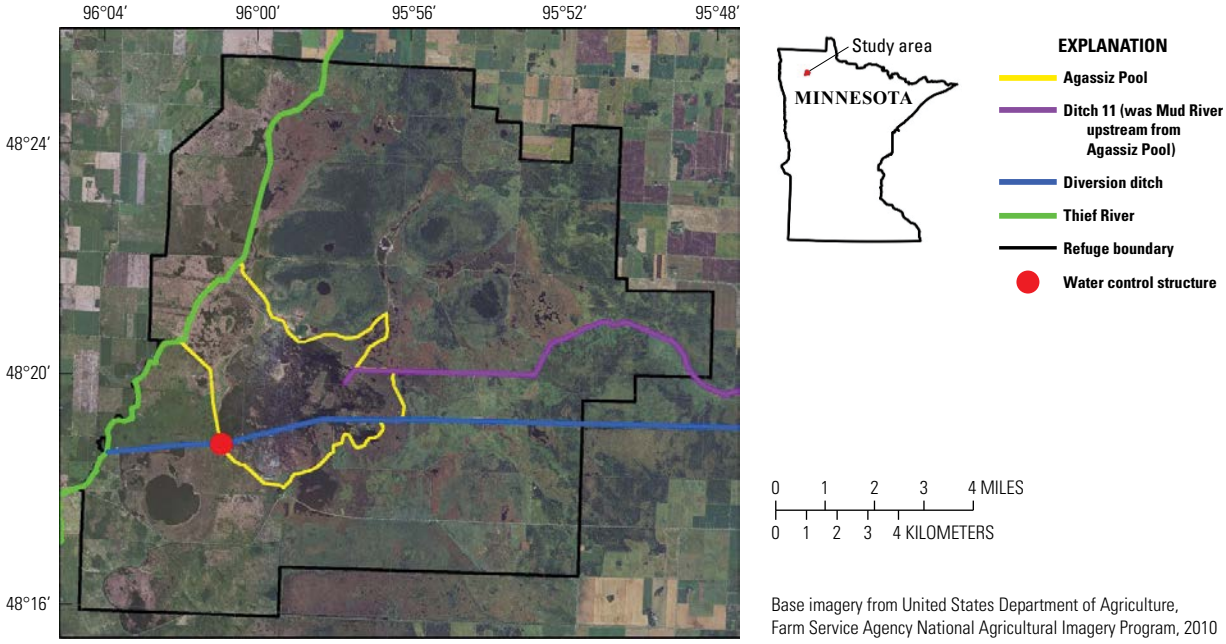
Products:

Post van der Burg, M., Jenni, K.E., Nieman, T.L., and Coleman, J.L., 2014, Charting a course forward—Identifying research and decisionmaking priorities in the Williston Basin, United States, chap D *of* Gleason, R.A., and Tangen, B.A., eds., Brine contamination to aquatic resources from oil and gas development in the Williston Basin, United States: U.S. Geological Survey Scientific Investigations Report 2014–5017, p. 115–127, https://doi.org/10.3133/sir20145017.

Post van der Burg, M., Thomas, C.C., Holcombe, T., and Nelson, R.D., 2016, Benefits and limitations of using decision-analytic tools to assess uncertainty and prioritize Landscape Conservation Cooperative information needs: Journal of Fish and Wildlife Management, v. 7, no. 1, p. 280–290, https://doi.org/10.3996/032015-JFWM-023.

Post van der Burg, M., Jenni, K.E., Nieman, T.L., Eash, J.D., and Knutsen, G.A., 2017, Understanding and finding solutions to the problem of sedimentation in the National Wildlife Refuge System: Journal of Fish and Wildlife Management, v. 8, no. 2, p. 648-660, https://doi.org/10.3996/012016-JFWM-004.

Collaborators: FWS, National Park Service, Plains and Prairie Potholes LCC, Eastern Tallgrass LCC, USACE



Map of Agassiz National Wildlife Refuge in northwestern Minnesota, which was being negatively impacted by sedimentation. A remediation strategy was developed during a structured decision-making workshop. Reproduced from Post van der Burg and others (2017).

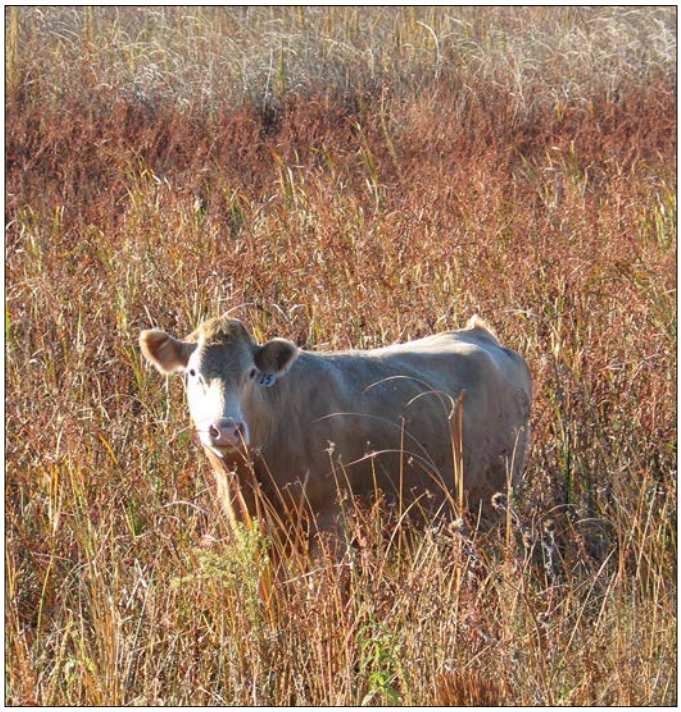
55. Data Integration and Information Synthesis

Integrating data from multiple sources across various spatial and temporal scales is a challenge that the NPWRC is taking on to facilitate more effective synthesis of information that is useful for understanding ecosystems and analysis of management decisions. A revitalized focus on data management and documentation during this past year is a foundation to future use of datasets in synthesis research. A large series of data from Cottonwood Lake Study Area in Stutsman County, North Dakota, as part of the Missouri Coteau Wetland Ecosystem Observatory, was documented and uploaded to USGS ScienceBase. These data are being used in the development of data integration and visualization tools as part of a partnership with the USGS Core Sciences Mission Area. The NPWRC has also provided additional support to a USGS Community for Data Integration funded project titled "Extending ScienceCache—a Mobile Application for Data Collection—to Accommodate Broader Use within USGS."

Contact: Mark T. Wiltermuth, mwiltermuth@usgs.gov, 701–253–5567

56. Managing Upland Vegetation as a Mitigation Strategy for Climate Change Impacts on Prairie-pothole Wetlands

The goal of this research is to increase knowledge of climate change effects on prairie-pothole wetlands and the ability of the wetlands to provide habitat to breeding waterfowl, and to identify potential upland management strategies (for example, burning, grazing) with the potential to mitigate negative effects. Wetland simulation models indicate that climate change may result in increased drying of prairie-pothole wetlands as increased evapotranspiration associated with warmer temperatures outpace increases in precipitation. Resultant effects include reduced water depths and volumes and shorter hydroperiods, with seasonal wetlands being most vulnerable. In this effort, we performed an in-depth literature review of climate-change effects on wetland ecosystems and upland management techniques with potential to mitigate identified effects. We also completed a field study in which uplands surrounding 12 prairie-pothole wetlands received burning, grazing, and control treatments. The literature review was published as a USGS Scientific Investigations Report. Results of this study can be used to inform upland management decisions made by land managers in efforts directed at influencing water levels in prairie-pothole wetlands.



Cattle grazing and other upland-management techniques can be used to mitigate potential climate-change effects on wetland water volumes through effects on snowmelt and precipitation runoff. Photograph by David M. Mushet, U.S. Geological Survey.

Contact: David M. Mushet, dmushet@usgs.gov, 701–253–5558

Products:

Renton, D.A., Mushet, D.M., and DeKeyser, E.S., 2015, Climate change and upland management effects on prairie-pothole wetlands—A literature review: U.S. Geological Survey Scientific Investigations Report 2015–5004, 21 p., https://doi.org/10.3133/sir20155004.

Renton, D.A., 2016, Managing upland vegetation as a mitigation strategy for climate-change effects on prairie-pothole wetlands: Fargo, North Dakota, North Dakota State University, MS Thesis, 90 p.

Collaborators: FWS, Chase Lake Wetland Management District; North Dakota State University

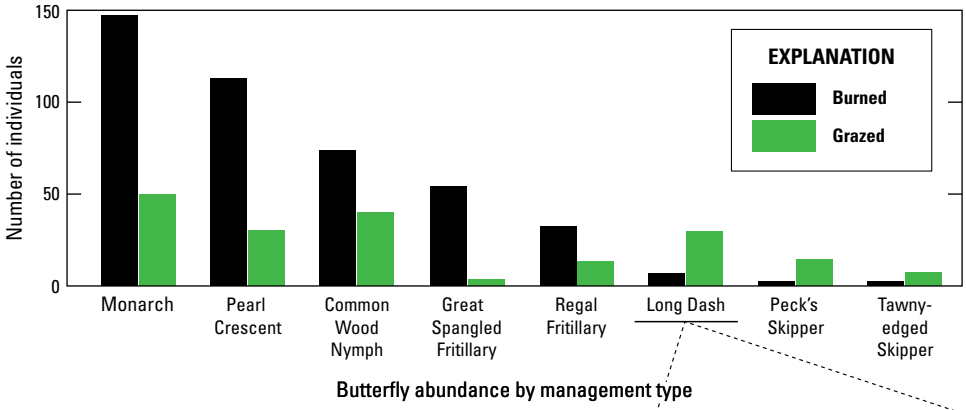
Invasive Species

57. Evaluation of Conservation Grazing Compared to Prescribed Fire to Manage Tallgrass Prairie Remnants for Plant and Pollinator Species Diversity

With scarcely 2 percent of native tallgrass prairie remaining today, it is imperative that we wisely manage what little remains to conserve prairie-dependent plants, pollinators, and other animals and ecosystem processes. Two commonly used methods of prairie management are prescribed fire and conservation grazing. Either method may present tradeoffs with respect to conservation of vulnerable plant, bee, or butterfly species, but at present those tradeoffs are not well described and resource managers do not have all the information necessary to develop optimal management plans for their goals. With this study, funded by the Minnesota Environment and Natural Resources Trust Fund, we aim to fill that knowledge gap by characterizing effects on bees and butterflies that are related to the management practice itself compared to those effects mediated by management-caused changes in vegetation. Further, we will relate bee and butterfly life history traits to their responses to fire and grazing to clarify if results can be generalized or are species-specific.

Contact:
Diane L. Larson,
dlarson@usgs.gov,
651–649–5041

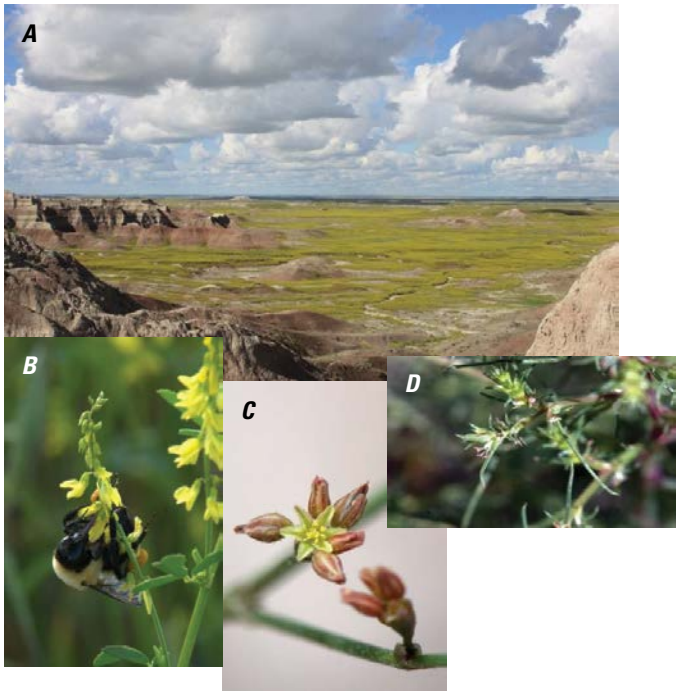
Collaborators: FWS, Morris Wetland Management District; Minnesota Department of Natural Resources, Division of Parks and Trails, and Prairie Conservation Plan; University of Minnesota; The Nature Conservancy; and private landowners in western Minnesota



Several species of butterflies varied in abundance between burned (black bars) and grazed (green bars) sites. Some of the least commonly encountered butterflies were present only on grazed sites (pooled 2016 and 2017 counts).

58. Effects of Invasive Plant Species on Reproduction of the Rare Endemic Plant Dakota Buckwheat (*Eriogonum visheri*) at Badlands National Park

Endemism in plants is extremely uncommon in the Great Plains. Dakota buckwheat is a rare, endemic plant present in only a few locations at Badlands National Park and sites with similar soils outside the park. In an earlier study, the NPWRC inferred that of two common, coflowering invasive plants, Russian thistle was more likely than yellow sweetclover to interfere with Dakota buckwheat pollination. This inference was based on an analysis that grouped pollinating insects and flowering plants into groups, called "modules," in which pollinators and plants were statistically more likely to interact with each other than with those outside their module. In this study, we explicitly test the impact of these two invasive plants on visitation, pollen limitation, and seed set of Dakota buckwheat. By doing the meticulous work this study requires, we will be able to better interpret other studies that only investigate visitation without assessing seed set and provide managers with information needed to manage invasive plants near this rare endemic plant.



Contact: Diane L. Larson, dlarson@usgs.gov, 651–649–5041

Collaborators: National Park Service, Badlands National Park

Our study system is at Badlands National Park, where in some years yellow sweetclover dominates the landscape. *A*, Bumblebees often visit yellow sweetclover flowers; *B*, smaller bees, such as sweatbees, prefer Dakota buckwheat; *C*, Russian thistle; or *D*, flowers. Photographs by Milt Haar (*A*) and Diane L. Larson (*B–D*), U.S. Geological Survey.

59. Evaluation of Tallgrass Prairie Restoration Methods to Improve Resistance to Invasive Species and Maintenance of Plant Species Diversity Over Time

Patience is necessary when reconstructing native tallgrass prairie from abandoned farmland. In this research effort, we observed that as reconstructions matured, Canada thistle cover declined even though herbicides were not applied. There is no single best planting method for all situations. Ten years after planting, cover of planted, native nonplanted, and exotic species varied little among three planting methods (dormant-season broadcast, growing-season broadcast, growing-season drill) used in this study. Planting a seed mix with more species did result in reconstructions that harbored more species, but at the cost of lower proportional success. Exotic cool-season grasses may be the biggest threat to these reconstructions. None of the planting methods or seed mix richness levels slowed their increase. Knowledge gained from this research effort is useful to land managers aiming to improve invasion resistance in tallgrass prairie restorations.

Typical early establishing species in a prairie reconstruction planted with a low-diversity seed mix. Photograph by Diane L. Larson, U.S. Geological Survey.

Contact: Diane L. Larson, dlarson@usgs.gov, 651–649–5041

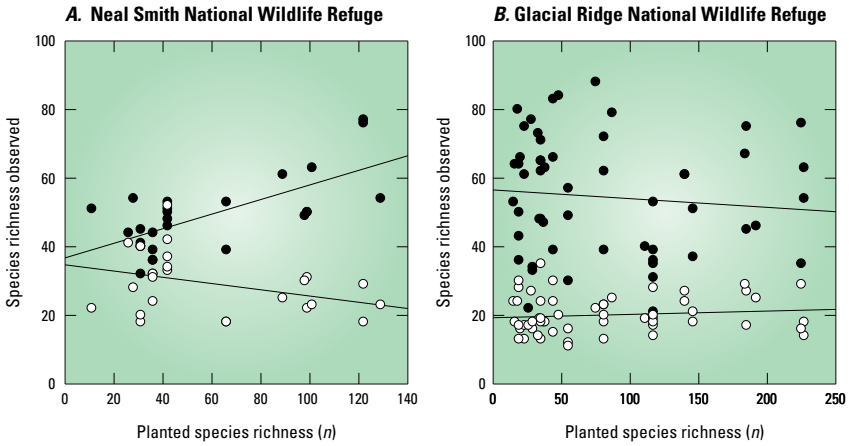
Products:

Larson, D.L., Bright, J.B., Drobney, P., Larson, J.L., and Vacek, S., 2017, Persistence of native and exotic plants 10 years after prairie reconstruction: Restoration Ecology, v. 25, no. 6, p. 953–961, https://doi.org/10.1111/rec.12521.

Larson, D.L., Bright, J.B., Drobney, P., Larson, J.L., and Vacek, S., 2016, Persistence of native and exotic plants ten years after prairie reconstruction data set: U.S. Geological Survey data release, https://doi.org/10.5066/F70C4SZ0.

Collaborators: FWS, Neal Smith National Wildlife Refuge, Litchfield Wetland Management District, Fergus Falls Wetland Management District, and Morris Wetland Management District

60. Developing Evaluation and Monitoring Frameworks for Tallgrass Prairie Reconstruction



Ideally, we would see an increase in observed native species richness and a decline in introduced species richness as a greater number of species are planted. Such a pattern was evident at *A*, Neal Smith National Wildlife Refuge but not at *B*, Glacial Ridge National Wildlife Refuge. Open circles represent introduced species and closed circles represent native species.

Tallgrass prairie species are planted on thousands of hectares of retired farmland each year. If the methods used and resulting characteristics of these prairies are recorded, compiled, and analyzed, they can provide a valuable resource for evaluating seed mixes, planting methods, and post-planting management. Toward this end, collaborators in the Prairie Reconstruction Initiative, funded by the FWS, developed a database to make data such as these available to researchers and the public. To begin this effort and to illustrate what can be learned by keeping good records of reconstructions, we gathered data from two refuges consisting of reconstructed prairies and evaluated the utility of retrospective information on planting methods, seed mix characteristics, and post-planting management in predicting reconstruction outcomes. Information gained from this effort will be useful for tallgrass-prairie evaluation and monitoring efforts in the Northern Great Plains.

Contact: Diane L. Larson, dlarson@usgs.gov, 651–649–5041

Products:

Larson, D.L., Ahlering, M., Drobney, P., Esser, R., Larson, J.L., Viste-Sparkman, K., in press, Developing a framework for tallgrass prairie reconstruction methods and management: Ecological Restoration.

Larson, D.L., Ahlering, M.A., Drobney, P., Esser, R., Larson, J.L., and Viste-Sparkman, K., 2017, Developing a framework for evaluating tallgrass prairie reconstruction methods and management: U.S. Geological Survey data release, https://dx.doi.org/10.5066/F72N50RJ.

Collaborators: FWS, Neal Smith National Wildlife Refuge and Glacial Ridge National Wildlife Refuge; The Nature Conservancy; The Prairie Reconstruction Initiative

61. Improving Wildlife Habitat Through Management and Restoration of Native Prairies on Lands Under FWS Ownership

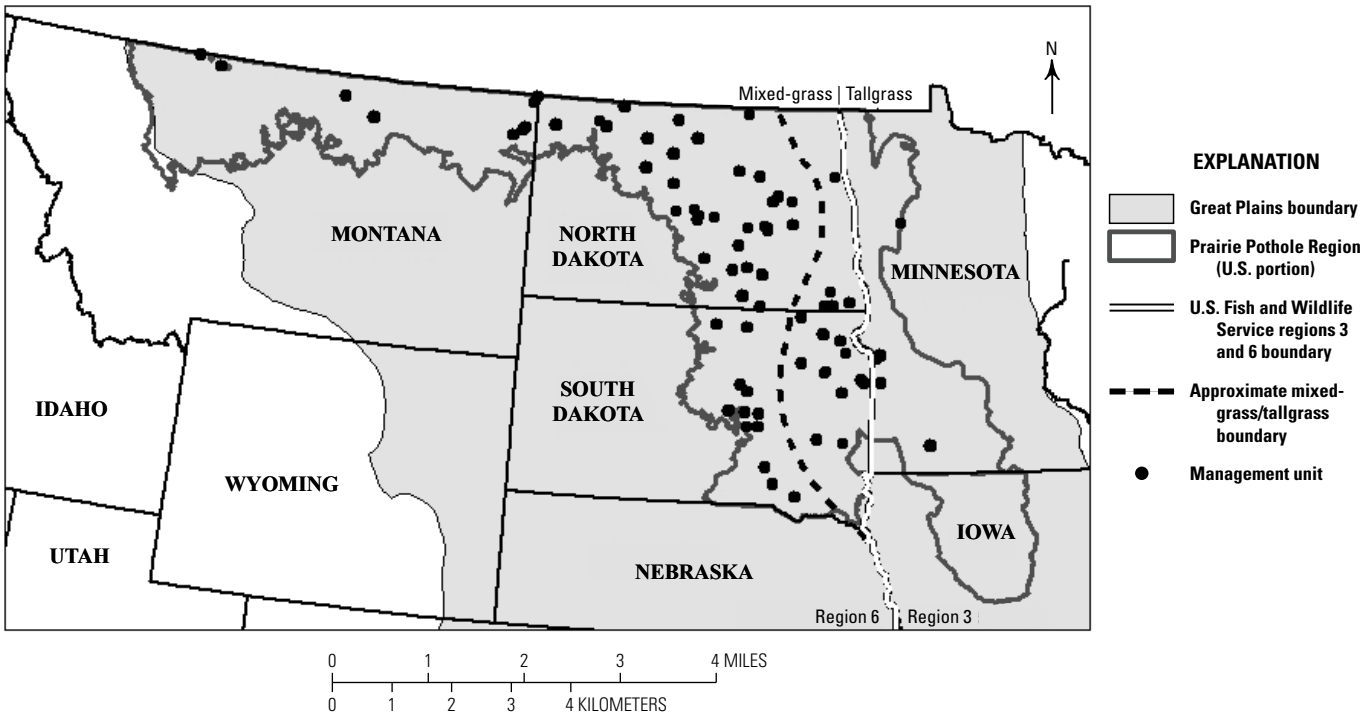
The extent of native prairie throughout the north-central United States has sharply declined since European settlement, and much of what remains has been invaded by introduced cool-season grasses, reducing floristic diversity and quality. On lands under its ownership, the FWS is working to restore native prairie integrity by reducing introduced species under the Native Prairie Adaptive Management (NPAM) program. Restoration actions consist of forms and timing of defoliation, including burning and grazing. Each year, managers face a difficult decision about whether to defoliate a prairie, and if so, which defoliation treatment to employ given the current type and degree of invasion and recent history of defoliation. Managers desire to learn about effectiveness and efficiency of these approaches through the decision-making and implementation process. The NPAM program provides real-time decision support to managers with the objective of increasing the cover of native grasses and forbs.

Contact: Terry L. Shaffer, tshaffer@usgs.gov, 701–253–5522

Collaborators: FWS (lead agency), National Wildlife Refuge System, Refuge Cooperative Research Program, and Inventory and Monitoring Program; USGS, Georgia Cooperative Fish and Wildlife Research Unit

Products:

Moore, C.T., Gannon, J.J., Shaffer, T.L., and Dixon, C.S., in press, An adaptive approach to vegetation management in native prairies of the Northern Great Plains, *in* Runge, M.C., Converse, S.J., Lyons, J.E., and Smith, D.R., eds., Case studies in decision analysis for natural resources management: Baltimore, Maryland, Johns Hopkins University Press.



Extent of the mixed-grass and tallgrass prairies in the Great Plains of the northern United States. The U.S. Fish and Wildlife Service (FWS) management units enrolled in the Native Prairie Adaptive Management (NPAM) program are contained within the U.S. portion of the Prairie Pothole Region, an ecoregion of soils and topography formed by glacial activity. The dashed line is the approximate demarcation of the mixed-grass (westerly) and tallgrass prairie (easterly) systems. Refuges from two FWS regions (3 and 6) participate in the NPAM program. Graphic from Moore and others (in press).

62. Decision Support for Restoration and Management of FWS-owned Native Prairies—Implications for Grassland Bird Communities

Temperate grasslands are considered one of the most altered ecosystems in the world. Remaining prairies have been increasingly degraded by fragmentation, encroachment by woody and exotic plants, and suppression or misapplication of defoliation disturbances (for example, fire, grazing, haying). More than 100,000 hectares of native tallgrass and mixed-grass prairies are managed by the FWS in the Northern Great Plains. Although prairies in this region evolved with grazing, fire, and climatic variability, management of FWS grasslands often has been passive and involved extended periods of rest. Extended rest has been implicated as a contributing factor in large-scale invasions by woody vegetation, smooth brome, Kentucky bluegrass, and other cool-season exotic plants. In

Biological science technician surveying breeding birds on a grassland managed by the U.S. Fish and Wildlife Service. Photograph by Monica Daane, U.S. Geological Survey.

2008, the USGS and the FWS initiated a collaborative effort, the NPAM program. The NPAM program employs the principles of adaptive management to evaluate and improve management practices that address invasive plant issues and restoration efforts on FWS grasslands with time. Realistically, shifts in vegetation with time also may affect habitat quality and quantity for grassland birds, which have exhibited widespread declines in North America. In collaboration with the FWS, the NPWRC initiated a companion study that leverages the NPAM program effort to develop competing models for the response of grassland breeding birds to management treatments. The primary objectives of this study are to assess the response of grassland birds to various management treatments (rest, fire, grazing) that are being implemented to restore vegetation composition on FWS-owned grasslands, and to explore the effects of vegetation structure and composition as mechanisms for triggering grassland bird responses to management.

Contact: Lawrence D. Igl, ligl@usgs.gov, 701–253–5511

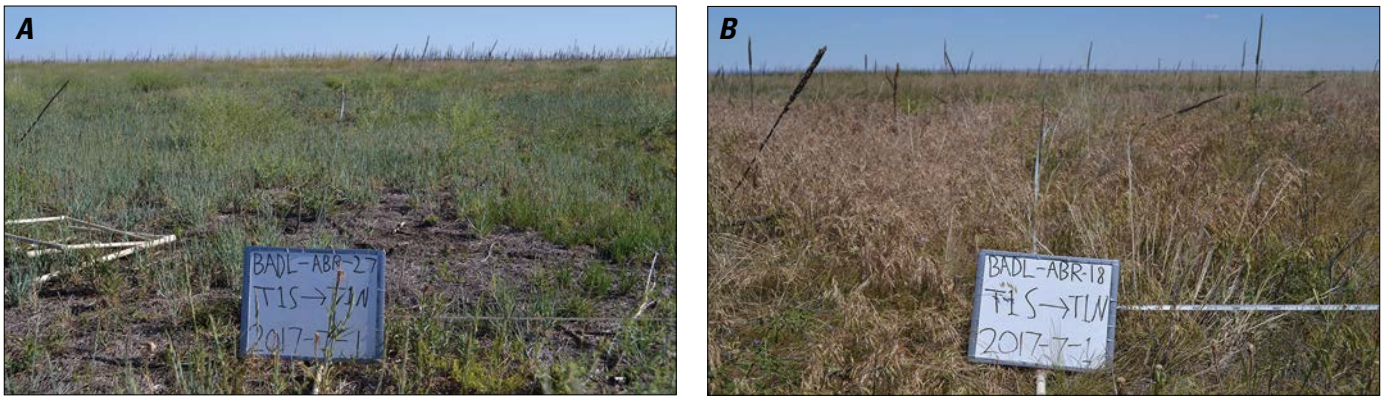
Collaborators: FWS: Arrowwood National Wildlife Refuge Complex, Audubon National Wildlife Refuge Complex, Big Stone National Wildlife Refuge, Detroit Lakes Wetland Management District, Devils Lake Wetland Management District, Huron Wetland Management District, Kulm Wetland Management District, Lake Andes National Wildlife Refuge, Long Lake Wetland Management District, Lostwood National Wildlife Refuge Complex, Madison Wetland Management District, Medicine Lake National Wildlife Refuge, Morris Wetland Management District, Sand Lake National Wildlife Refuge Complex, Souris River Basin National Wildlife Refuge Complex, Tewaukon Wetland Management District, Waubay National Wildlife Refuge Complex, and Windom Wetland Management District

63. What Role Does Prescribed Fire Play in Managing Annual Bromes in Northern Great Plains Grasslands?

Prescribed fire is used in grasslands throughout the Northern Great Plains National Park Service units (parks) to manage fuel loads, control nonnative species, and maintain a vital ecosystem process. Serious concerns about its use in areas with invasive annual brome grasses have arisen. Prescribed fire may be beneficial for controlling annual bromes when they are not abundant, but burning in sites dominated by annual bromes may do more harm than good. Using an experimental approach at two parks in South Dakota and Nebraska, this project seeks to determine the efficacy of prescribed fire as an annual brome management tool across a range of infestation levels and to understand if followup herbicide application or seed addition improves adverse effects or enhances positive effects of fire. Project results will reduce uncertainty about how to maintain fire as a vital ecosystem process while also supporting other vegetation management goals in Northern Great Plains parks.

Contact: Amy J. Symstad, asysmstad@usgs.gov, 605–745–1191

Collaborators: National Park Service, Badlands National Park, Scotts Bluff National Monument, Northern Great Plains Fire Management Office, and Northern Great Plains Exotic Plant Management Team



Examples of grassland response to experimental fire treatments: *A*, Experimental plots burned in fall alone or followed up with a pre-emergent herbicide had lower invasive annual brome grass cover than *B*, unburned, untreated plots 1 year after treatment, but effectiveness of these treatments varies depending on the timing of their application. Photographs by U.S. Geological Survey.

64. An Adaptive Management Framework to Control Invasive Annual Brome Grasses in Northern Great Plains Parks (Annual Brome Adaptive Management Project)

Invasion by annual brome grasses (cheatgrass and Japanese or field brome) into National Park Service units (parks) in the Northern Great Plains impacts park historical and ecological integrity by reducing native plant diversity and altering ecosystem functioning. Parks currently implement few management actions targeting annual bromes, and consequently these species persist and have even increased in some parks. Uncertainty about the effectiveness of specific management treatments in controlling annual bromes and limited capacity to apply management treatments make the problem of managing bromes complex. The Annual Brome Adaptive Management project is tackling this problem through a cooperative effort between the NPWRC and seven parks and their supporting management and monitoring networks. The Annual Brome Adaptive Management project is developing a structured adaptive management framework that will guide parks and their supporting networks in making more effective and strategic vegetation management decisions.

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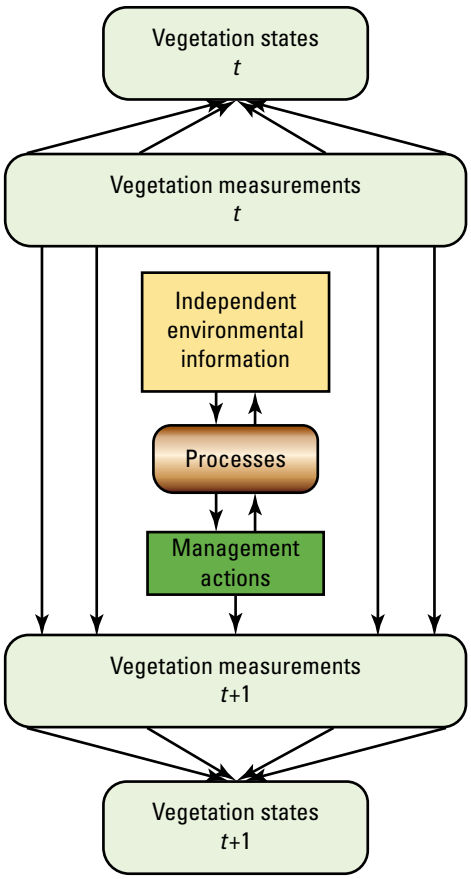
Collaborators: National Park Service, Agate Fossil Beds National Monument, Badlands National Park, Devils Tower National Monument, Fort Laramie National Historic Site, Little Bighorn Battlefield National Monument, Scotts Bluff National Monument, Wind Cave National Park, Northern Great Plains Exotic Plant Management Team, Northern Great Plains Fire Management Office, Northern Great Plains Inventory and Monitoring Network, Northern Rocky Mountains Exotic Plant Management Team, Rocky Mountain Inventory and Monitoring Network



A highly simplified representation of the principal model of the annual brome structured adaptive management framework.

65. Grazing Resources for Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota

Badlands National Park contains one of the largest protected expanses of mixed-grass prairie in the United States, much of which supports a herd of nearly wild bison. The park nevertheless is too small to accommodate bison's natural nomadic behavior, which in the past resulted in their ephemeral but intense influence on Great Plains grasslands. Consequently, active management of the number of bison in the park, and to some degree where the bison spend their time, is necessary to conserve the plant species and communities on which the bison and other wildlife depend. This research is assessing the spatial distribution of productivity, composition, and consumption of park vegetation; the location and condition of constructed water resources in the park; and temporal variation of bison diet. Results will be used to determine the departure of the park's current vegetation from desired conditions under current management strategies, as well as the park's capacity to simultaneously support desired vegetation conditions and more bison. A companion project is assessing the temporal and spatial distribution of bison in the park using GPS collars. Combined results from these two studies will be used to explore the feasibility of various bison population and vegetation objectives under different management and weather scenarios. These evaluations are key for National Park Service managers to determine a successful management strategy for the mutual benefit of native prairie and bison at Badlands National Park.

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Fish and Wildlife Disease

66. Effects of Population Density on Prevalence of Chronic Wasting Disease (CWD), Physical Condition, and Vital Rates of Elk at Wind Cave National Park, South Dakota

CWD is a degenerative neurological disease caused by infectious proteins called prions. Although documented cases are invariably fatal, infected elk commonly survive for several months or longer, passing prions directly to other individuals and into the environment, where they bind to surfaces or soils and can persist for years. CWD reached Wind Cave National Park about 1997 and rapidly became the leading cause of mortality for adult elk. By 2016, prevalence reached about 24 percent in the eastern park, an unsustainable level that threatens persistence of the population. Although CWD constitutes a crisis for park management, it also presents an unprecedented opportunity for studying effects of population density on CWD prevalence, physical condition, and vital rates of elk. During 2016–17, the National Park Service removed 262 elk from Wind Cave National Park, reducing the population by about one-half. We are working with National Park Service partners to evaluate effects of the reduction and develop guidance for management of CWD and high-density elk populations not only at Wind Cave National Park, but in other parks and preserves.

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Collaborators: National Park Service, Wind Cave National Park, Biological Resources Division, and Midwest Regional Office

A bull elk with chronic wasting disease at Wind Cave National Park. The emaciated appearance and drooping ears are characteristic of latter stages of infection. Photograph by National Park Service.

References

Anteau, M.J., and Afton, A.D., 2008, Using plasma-lipid metabolites to index changes in lipid reserves of free-living Lesser Scaup (*Athya affinis*): Auk, v. 125, no. 2, p. 354–357, https://doi.org/10.1525/auk.2008.06255.

Anteau, M.J., Wiltermuth, M.T., Post van der Burg, M., and Pearse, A.T., 2016, Prerequisites for understanding climate-change impacts on northern prairie wetlands: Wetlands, v. 36, supplement 2, p. 299–307, https://doi.org/10.1007/s13157-016-0811-2.

Austin, J.E., Shaffer, T.L., Igl, L.D., Johnson, D.H., Krapu, G.L., Larson, D.L., Mech, L.D., Mushet, D.M., and Sovada, M.A., 2017, Northern Prairie Wildlife Research Center—Celebrating 50 years of science: U.S. Geological Survey Circular 1434, 27 p., https://doi.org/10.3133/cir1434.

McKenna, O.P., Mushet, D.M., Rosenberry, D.O., and LaBaugh, J.W., 2017, Evidence for a climate-induced eco-hydrological state shift in wetland ecosystems of the southern prairie pothole region: Climatic Change, v. 145, no. 3–4, p. 273–287, https://doi.org/10.1007/s10584-017-2097-7.

Moore, C.T., Gannon, J.J., Shaffer, T.L., and Dixon, C.S., in press, An adaptive approach to vegetation management in native prairies of the Northern Great Plains, *in* Runge, M.C., Converse, S.J., Lyons, J.E., and Smith, D.R., eds., Case studies in decision analysis for natural resources management: Baltimore, Maryland, John Hopkins University Press.

Post van der Burg, M., Jenni, K.E., Nieman, T.L., Eash, J.D., and Knutsen, G.A., 2017, Understanding and finding solutions to the problem of sedimentation in the National Wildlife Refuge System: Journal of Fish and Wildlife Management, v. 8, no. 2, p. 648-660, https://doi.org/10.3996/012016-JFWM-004.

Stewart, R.E., and Kantrud, H.A., 1971, Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92: Washington, D.C., U.S. Fish and Wildlife Service, 57 p.

U.S. Geological Survey, 2017, Northern Prairie Wildlife Research Center publications and reports—1960–2015: U.S. Geological Survey data release, https://doi.org/10.5066/F7QZ28ZD.

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Publishing support provided by the
Rolla Publishing Service Center

Facing page. An aerial view of the Prairie Pothole Region. Photograph by USGS.

Inside back cover. Midcontinent River (by Jennifer Stucker, USGS).

Back cover. Northern Prairie Wildlife Research Center in February 2019 (by Mark Sherfy, USGS).

Sherfy, M.H., ed.—**U.S. Geological Survey—Northern Prairie Wildlife Research Center 2017 Research Activity Report**—Circular 1451

ISBN 978-1-4113-4285-9

ISSN 1067-084X (print)
ISSN 2330-5703 (online)
https://doi.org/10.3133/cir1451